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ABSTRACT

Objectives, topics/understandings to be taught, and teachers notes are provided for the seven units in this Regents biology syllabus. Units and major topic areas include: (1) unity and diversity among living things (concept of life, diversity/unity of life); (2) maintenance in living things (nutrition, transport, respiration, excretion, regulation, locomotion); (3) human physiology (nutrition, transport, respiration, excretion, regulation, locomotion); (4) reproduction and development (asexual reproduction, sexual reproduction); (5) transmission of traits from taught, and teachers generation to generation (foundations of genetics, genetics concepts, mutations, genetic applications to animal/plant breeding, interaction of heredity and environment, human heredity, modern genetics); (6) evolution (evolution, evolution theory, heterotroph hypothesis); and (7) ecology, ecological organization, ecosystems, biosphere and humans). A topical outline, safety suggestions, information on the role of the laboratory, and a list of laboratory skills are included. Also included (in appendices) are guidelines for the development of district policies for eye protection, information on teaching creationism/evolution, guidelines for the use of vertebrate animals in New York State elementary/secondary schools, and information on publications related to writing in science, use of potentially hazardous materials, and use of hypodermic syringes/needles. (JN)

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Biology

REGENTS SYLLABUS

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FOREWORD

This syllabus has been developed by a statewide advisory committee and curriculum writers working in conjunction with the New York State Education Department. It contains seven core topics and five extended areas. Approximately 80 percent of the total class time should be spent on the seven core topics with the remaining time used in the development of any two extended areas.

It is intended that this course provide students with an awareness of the natural world, basic scientific concepts, stimulation of inductive reasoning, and a basic understanding of biological processes and generalizations.

Any changes in the syllabus that may become necessary will be brought to the attention of school principals by means of a supervisory letter from the Department. This process will help to update syllabus information between revisions.

There are a number of topics which are not directly addressed in the topical outline. However, these topics (safety, origins, humane treatment of animals, and writing skills) are very important because of their bearing upon science education in general. The Department's recommendations regarding these topics may be found in the Appendix on pp. 136-141.

Teachers have suggested that a resource supplement be developed for the syllabus. The information included in the supplement is the result of a series of regional meetings where teachers shared their ideas for presenting syllabus topics. Ideas in the supplement are keyed to asterisked topics in the syllabus. Instructions for using the supplement appear in the Supplement Introduction.

The considerable task of revising this syllabus could not have been accomplished without the significant contributions of the following individuals and school districts.

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This publication was produced by the Bureau of Science Education with the assistance of the Bureau of General Education Curriculum Development. *Thomas Boehm*, Associate in science education, and *Barry W. Jamason*, Associate in general education curriculum development, supervised its development.

CONTENTS

Page

FOREWORD iii

FEEDBACK SHEET vi

INTRODUCTION vii

- Safety Suggestions ix
- Laboratory Skills x
- Biology Laboratory Skill Evaluation Form xi

TOPICAL OUTLINE. xii

UNIT I -- UNITY AND DIVERSITY AMONG LIVING THINGS 2

UNIT II -- MAINTENANCE IN LIVING THINGS 20

UNIT III -- HUMAN PHYSIOLOGY 46

UNIT IV -- REPRODUCTION AND DEVELOPMENT 74

UNIT V -- TRANSMISSION OF TRAITS FROM GENERATION TO GENERATION 92

UNIT VI -- EVOLUTION 108

UNIT VII -- ECOLOGY 118

APPENDIX 136

- Development of District Policies for Eye Protection: Suggested Guidelines 136
- Creationism and Evolution 137
- Guidelines for the Use of Vertebrate Animals in Elementary and Secondary School Programs of New York State 138
- Writing in Science 141
- Other Recommendations 141

FEEDBACK SHEET

Teachers are encouraged to evaluate critically this new syllabus and to submit their critiques to the Bureau of Science Education. Please be as specific as possible.

The form to the right may be duplicated and used as a basis for evaluation. Use a separate sheet for each unit.

RETURN TO:

Thomas A. Boehm, Associate
Bureau of Science Education
NYS Education Department
Albany, NY 12234

BIOLOGY EVALUATION -- UNIT _____

Teacher's Name ______________________________

School ______________________________

School Address ______________________________

____

Comments ______________________________

____

____

- Which topics/understandings do you find most valuable? Explain.

- What changes could be made to improve the syllabus format or content?

INTRODUCTION

This revision of the Regents Biology Syllabus is an interpretation of feedback received from biology teachers throughout the State. The respondents suggested that the previous syllabus needed updating, reorganization, and increased emphasis on laboratory work.

This syllabus is designed to provide students with a background in the biological sciences which will:

- Interpret more effectively the increasing amount of scientific information disseminated by the mass media.
- Consider career opportunities that are evolving as a result of accelerating technological advances.
- Develop an increased awareness of the consequences that can result from the ways we interact with our environment.

Content and Sequence

This syllabus contains seven core topics and five extended areas. Approximately 80 percent of the total class time should be spent on the seven core topics with the remainder of the time used in the development of any two extended areas.

Core Topics	Unit	Suggested Percent of Total Course Time
Unity and Diversity Among Living Things	I	8 - 12
Maintenance in Living Things	II	15 - 25
Human Physiology	III	8 - 12
Reproduction and Development	IV	8 - 12
Transmission of Traits from Generation to Generation	V	8 - 12
Evolution	VI	8 - 12
Ecology	VII	8 - 12

Each extended area is set off within the syllabus by dotted lines and identified by the code letters shown below.

Extended Areas	Code	Location
Biochemistry	BC	Units I, II, and III
Human Physiology	HP	Unit III
Reproduction and Development	RD	Unit IV
Modern Genetics	MG	Unit V
Ecology	EC	Unit VII

This syllabus provides one sequence of topics for presenting the course. Other sequences that facilitate a logical development of the topics may be used.

Unit Format

Each unit contains a unit outline, a list of objectives, a topical outline and the major understandings to be developed, and references to teacher resource materials.

Time Recommendation

The minimum time recommended for this course is six periods per week for a weekly total of at least 240 minutes of instruction. A double period for laboratory is considered desirable for some of the suggested laboratory topics.

Role of the Laboratory

An effective laboratory experience is a basic component of this course. A wide variety of experiences designed to capitalize on local resources and interests should be used to attain the objectives specified for laboratory work. In some cases, teachers will find it appropriate for a laboratory experience to precede classroom discussion while on other occasions laboratory work can be used as an effective follow-up activity. It is vital that laboratory and class work be carefully integrated.

The importance of laboratory work is highlighted by the need to:

1. Stimulate the development of basic skills by providing experiences in recording and interpreting data and manipulating equipment.
2. Develop safety habits which are transferable to everyday situations in and out of school.
3. Provide first-hand experiences with some of the ways in which scientists collect, organize, and interpret data under controlled conditions.
4. Provide some first-hand experiences using activities which are associated with a variety of science-related careers.
5. Stimulate and maintain student interest while developing and reinforcing understandings basic to the course.

Laboratory Evaluation

The emphasis placed on the laboratory component of the course requires that the teacher be able to

evaluate student competencies in the laboratory. Students will be expected to become proficient in the 16 laboratory skills listed on page x of the introduction. The lab skills have been organized into three basic areas: pre-lab, (1-3), laboratory activities, (4-12), and post-lab skills, (13-16). Any single laboratory experience might include skills in all three areas.

The evaluation plan for assessing proficiency in these 16 laboratory skills consists of two components: 1) laboratory performance in the local school setting and, 2) written responses on the Regents examination.

1) Laboratory performance evaluation -

Six of the 16 laboratory skills are best assessed by the teacher observing the manipulative skills of students in a local school setting. It is the responsibility of the biology teacher to determine that these skills have been attained. A Biology Laboratory Skill Evaluation Form is included in the introduction on page xi. One copy is to be made by school personnel for each student. As each skill is satisfactorily completed, the date and the initials of both student and teacher are to be recorded on the evaluation form. Satisfactory completion of all six of these skills is required prior to admittance to the Regents examination. These completed forms must be filed with the student's written records of laboratory work for a period of six months after the completion of the course.

2) Written responses on the Regents examination -

All 16 laboratory objectives are subject to testing on the Regents examination.

Laboratory Requirement

The successful completion of the laboratory program, which is prerequisite for admission to the Regents examination in biology, requires that the student must:

1. Complete at least 30 full-time laboratory periods which may include field work. While the minimum laboratory requirements can be met by performing 30 experiences requiring 30 laboratory periods, it can also be met by utilizing the 30 laboratory periods on a lesser number of experiences.
2. Complete a satisfactory written report for each laboratory experience. (see Appendix p. 141.)
3. Demonstrate proficiency in those skills specified on the Biology Laboratory Skill Evaluation Form.

Resources

Teachers have suggested that a resource supplement be developed for the syllabus. The information included in the supplement is the result of a series of regional meetings where teachers shared their ideas for presenting syllabus topics. Ideas in the supplement are keyed to asterisked topics in the syllabus. Instructions for using the supplement appear in the Supplement Introduction.

SAFETY SUGGESTIONS

1. Students should not handle chemicals or equipment in the laboratory until they have been given specific instructions.
2. Instruct students to report at once any equipment in the laboratory that appears to be unusual or improper such as broken, cracked, or jagged apparatus, or any reactions that appear to be proceeding in an abnormal fashion.
3. Students should report any personal injury or damage to clothing to the teacher immediately no matter how trivial it may appear.
4. Be sure loose clothing and hair are prevented from coming in contact with any science apparatus, chemicals, or sources of heat or flame.
5. Laboratory materials should not be transported through hallways by unsupervised students or during the passing of classes.
6. Students should be given adequate instructions on the proper use of dissection instruments.
7. Students should be instructed never to taste or inhale directly unknown chemicals.
8. Students should be instructed not to pour reagents back into stock bottles or exchange stoppers.
9. Warn students of dangers involved in the handling of hot glassware or other equipment. Proper devices for handling should be available.
10. Electrical wiring should be checked for fraying, exposed wires, or loose connections.
11. Familiarize students with the location and use of the fire blanket, fire extinguisher, and eye baths.
12. Appropriate, specific, safety instructions should be given which are applicable to particular experiments.

LABORATORY SKILLS

Laboratory Skills * *Lab skills to be evaluated using Biology Laboratory Skill Evaluation Form on page xi.	Some Suggested Types of Laboratory Experiences (Numbers Refer to Laboratory Topics Listed in the Resource Section)						
	Unit I	Unit II	Unit III	Unit IV	Unit V	Unit VI	Unit VII
1. Formulate a question or define a problem and develop a hypothesis to be tested in an investigation.	1,2,7,8	1,2,3,4,	1,2,5		1,2,3,4, 5,7	1,2,3,4,	1-7
2. Given a laboratory problem, select suitable lab materials, safety equipment, and appropriate observation methods.	2,4,5,6, 7,8	1,2,6	1	2	3,4,5	1,3	1,2,3,6
3. Distinguish between controls and variables in an experiment.	5,8,9	1,2,3,4, 6	1,2,3,5	4	3,4	2,3	1,4,5,7
*4. Identify parts of a light microscope and their functions and focus in low and high power.	2-7	1,2,3,5 6,7	2,6	1,2,3,4	3		2,3,5,7
5. Determine the size of microscopic specimens in micrometers (microns).	2-7	2,5,6,7		1			2,3,5
*6. Prepare wet mounts of plant and animal cells and apply staining techniques using iodine or methylene blue.	2,3,4,5, 7	1,2,3,4, 5	2	1,2,3,4	3,6		2,3,5,7
*7. Identify cell parts under the compound microscope such as the nucleus, cytoplasm, chloroplast, and cell wall.	2,5,7	1,2,3,5		1	3		
8. Use and interpret indicators such as pH paper, Benedict's (Fehling's) solution, iodine (Lugol's) solution, and bromthymol blue.	8	1,2,4	1,4	4			4
*9. Use and read measurement instruments such as metric rulers, Centrigrade thermometer, and graduate cylinders.	6,7,8,9	1,2,4	2,3,4	4		2	1,2,6
*10. Dissect plant and animal specimens for the purpose of exposing major structures for suitable examination. Suggestions of specimens include seeds, flowers, earthworms, grasshoppers, etc.		1,3,4,5, 6,7	1,2,3,4, 5	3,4			3
*11. Demonstrate safety skills involved in heating materials in test tubes or beakers, use of chemicals, and handling of dissection instruments.	2,8	1,3,5,6	1,2,3,4, 5,6	3,4			3
12. Collect, organize, and graph data.	1,2,9	1,2,	1,3,5	3,4	1,2,3,4, 5,7	1,2,3	1,2,3,4, 6,7
13. Make inferences and predictions based upon data collected and observed.	1,2,5,7, 8,9	1-7	1,2,3,4, 5,6	1-4	1-7	1,2,3,4	1-7
14. Formulate generalizations or conclusions of the investigation.	1,2,3,4, 5,7,8,9	1-7	1,2,3,4, 5,6	1-4	1-6	1,2,3,4	1-7
15. Assess the limitations and assumptions of the experiment.	1,2,7,8, 9	1,2,3,4, 6,7	1,2,3,4, 5	1-4	1-6	2,3,4	1-7
16. Determine the accuracy and repeatability of the experimental data and observations.	1,2,7,8, 9	1,2,3,4, 6,7	1,2,3,4, 5	1-4	1-6	2,3,4	1-7

BIOLOGY LABORATORY SKILL EVALUATION FORM

Student ____________________

School ____________________

Teacher ____________________

Year ____________________

Upon demonstration of the ability to successfully perform each of the following skills (as described on page x of the syllabus) both the student and the teacher are to initial this form.

1. Focus a compound light microscope (low and high power).

   Date _______ Student _______ Teacher _______

2. Prepare wet mounts and apply staining techniques.

   Date _______ Student _______ Teacher _______

3. Identify cell parts under the compound light microscope.

   Date _______ Student _______ Teacher _______

4. Select and read instruments used for measurement.

   Date _______ Student _______ Teacher _______

5. Dissect plant and animal specimens.

   Date _______ Student _______ Teacher _______

6. Demonstrate safety skills.

   Date _______ Student _______ Teacher _______

TOPICAL OUTLINE

UNIT I -- UNITY AND DIVERSITY AMONG LIVING THINGS

- I. Concept of Life
  - A. Definition
  - B. Life Functions
    - 1. Nutrition
    - 2. Transport
    - 3. Respiration
    - 4. Excretion
    - 5. Synthesis
    - 6 Regulation
    - 7. Growth
    - 8. Reproduction
  - C. Metabolism
  - D. Homeostasis

- II. Diversity of Life
  - A. Necessity for Classification
  - B. A Scheme of Classification
  - C. Nomenclature

- III. Unity of Life
  - A. Structure of Living Organisms
    - 1. Cell Theory
      - a. Historical Background
      - b. Methods of Cell Study
        - 1) Instrumentation
        - 2) Measurement
        - 3) Techniques
      - c. Cell Organelles
    - 2. Exceptions to the Cell Theory
  - B. Chemistry of Living Organisms
    - *1. Chemical Elements in Living Matter
    - *2. Chemical Compounds in Living Matter
      - a. Inorganic Compounds
      - b. Organic Compounds
        - 1) Carbohydrates
          - a) Composition
          - b) Examples
          - c) Functions
        - 2) Lipids
          - a) Composition
          - b) Examples
          - c) Functions
        - 3) Proteins
          - a) Composition
          - b) Examples
          - c) Functions
    - *3. Chemical Control
      - a. The Role of Enzymes
        - 1) Structure
          - a) Protein Nature
          - b) Active Site
        - 2) Function
          - a) Enzyme-Substrate Complex
          - b) "Lock and Key" Model
      - b. Factors Influencing Action of Enzymes
        - 1) Temperature
        - 2) Relative Amounts of Enzyme and Substrate
        - 3) pH

UNIT II -- MAINTENANCE IN LIVING THINGS

- *I. Nutrition
  - A. Autotrophic Nutrition
    - 1. Process of Photosynthesis
      - a. Significance
      - b. Process
      - c. Results
    - 2. Adaptations for Photosynthesis
  - B. Heterotrophic Nutrition

TOPICAL OUTLINE

- 1. Processes for Heterotrophic Nutrition
  - a. Ingestion
  - b. Digestion
    - 1) Mechanical Breakdown
    - 2) Chemical Digestion
  - c. Egestion
- 2. Adaptations for Heterotrophic Nutrition
  - a. Fungi
  - b. Protozoans
  - c. Animals
    - 1) Hydra
    - 2) Earthworm
    - 3) Grasshopper
    - 4) Human

- *II. Transport
  - *A. Process
    - 1. Absorption
      - a. Structure of the Cell Membrane
      - b. Function of the Cell Membrane
        - 1) Passive Transport
        - 2) Active Transport
        - 3) Pinocytosis
        - 4) Phagocytosis
    - *2. Circulation
  - *B. Adaptations
    - 1. Plants
      - a. Roots
        - 1) Root Hairs
        - 2) Xylem
        - 3) Phloem
      - b. Stems
      - c. Leaves
    - 2. Animals
      - a. Hydra
      - b. Earthworm
      - c. Grasshopper
      - d. Human

- III. Respiration
  - A. Process
    - 1. Cellular
      - a. Anaerobic Respiration (Fermentation)
        - 1) Description
        - 2) Chemical Aspects
      - b. Aerobic Respiration
        - 1) Description
        - 2) Chemical Aspects
    - 2. Gas Exchange
  - B. Adaptations
    - 1. Monera, Protista, and Fungi
    - 2. Plants
      - a. Leaves
      - b. Stems
      - c. Roots
    - 3. Animals
      - a. Hydra
      - b. Earthworm
      - c. Grasshopper
      - d. Human

- *IV. Excretion
  - *A. Process
    - 1. Products
    - 2. Results
  - B. Adaptations
    - 1. Protista
      - a. Freshwater Protozoans
      - b. Algae
    - 2. Plants
    - 3. Animals
      - a. Hydra
      - b. Earthworm
      - c. Grasshopper
      - d. Human

TOPICAL OUTLINE

- V. Regulation
  - A. Nerve Control
    - 1. Functional Definitions
      - a. Stimulus
      - b. Receptors
      - c. Impulse
      - d. Response
      - e. Effectors
      - f. Neuron
        - 1) Dendrites
        - 2) Cyton
        - 3) Axon
        - 4) Terminal Branches
      - g. Synapse
      - h. Neurotransmitters
    - 2. Adaptations in Animals
      - a. Hydra
      - b. Earthworm
      - c. Grasshopper
      - d. Human
  - B. Chemical Control
    - 1. Chemical Control in Plants
      - a. Characteristics of Plant Hormones
      - b. Role of Plant Hormones
    - 2. Chemical Control in Animals
      - a. Endocrine Control
      - b. Role of Animal Hormones

- *VI. Locomotion
  - A. Advantages
  - B. Adaptations
    - 1. Protista
      - a. Algae
      - b. Protozoans
    - 2. Animals
      - a. Hydra
      - b. Earthworm
      - c. Grasshopper
      - d. Human

UNIT III -- HUMAN PHYSIOLOGY

- *I. Nutrition
  - A. Functional Organization
    - 1. Oral Cavity
    - 2. Esophagus
    - 3. Stomach
    - 4. Small Intestine
      - a. Chemical Digestion
      - b. Absorption
    - 5. Large Intestine
  - B. Mechanism for Chemical Digestion
  - C. Some Malfunctions of the Digestive System
    - 1. Ulcers
    - 2. Constipation
    - 3. Diarrhea
    - 4. Appendicitis
    - 5. Gallstones

- *II. Transport
  - *A. Functional Organization
    - *1. Transport Media
      - a. Blood
        - 1) Plasma
        - 2) Red Blood Cells
        - 3) Platelets
        - 4) White Blood Cells
          - a) Phagocytic White Blood Cells
          - b) Lymphocytes
            - (1) Immunity
              - (a) Active Immunity
              - (b) Passive Immunity
            - (2) Allergies
            - (3) Applications
              - (a) Blood Typing
              - (b) Organ Transplants
      - b. ICF and Lymph
    - 2. Transport Vessels
      - a. Arteries

TOPICAL OUTLINE

- b. Capillaries
- c. Veins
- d. Lymph Vessels
- *3. Transport Mechanisms
  - a. Structure and Function
    - 1) Circulation Through the Heart
    - 2) Pulmonary and Systematic Circulation
    - 3) Coronary Circulation
    - 4) Lymphatic Circulation
- B. Some Malfunctions of the Transport System
  - 1. Cardiovascular Diseases
    - a. High Blood Pressure
    - b. "Heart Attack"
      - 1) Coronary Thrombosis
      - 2) Angina Pectoris
  - 2. Blood Conditions
    - a. Anemia
    - b. Leukemia

- III. Respiration
  - A. Cellular
  - B. Gas Exchange
    - 1. Functional Organization of the Respiratory System
      - a. Nasal Cavity
      - b. Pharynx
      - c. Trachea
      - d. Bronchi
      - e. Bronchioles
      - f. Alveoli
      - g. Lung
    - 2. Mechanisms for Gas Exchange
      - a. Breathing
      - b. Gas Exchange
  - C. Some Malfunctions of the Respiratory System
    - 1. Bronchitis
    - 2. Asthma
    - 3. Emphysema

- *IV. Excretion
  - A. Functional Organization
    - 1. Lungs
    - 2. Liver
    - 3. Sweat Glands of the Skin
    - 4. Urinary System
      - a. Kidneys
      - b. Ureter
      - c. Urinary Bladder
      - d. Urethra
  - B. Malfunctions
    - 1. Kidney Diseases
    - 2. Gout

- *V. Regulation
  - A. Nervous System
    - 1. Functional Organization
      - a. Neurons
        - 1) Sensory Neurons
        - 2) Motor Neurons
        - 3) Interneurons
      - b. Nerves
      - c. Central Nervous System
        - 1) Brain
          - a) Cerebrum
          - b) Cerebellum
          - c) Medulla
        - 2) Spinal Cord
      - d. Peripheral Nervous System
        - 1) Somatic Nervous System
        - 2) Autonomic Nervous System
    - 2. Some Malfunctions of the Nervous System
      - a. Cerebral Palsy
      - b. Meningitis
      - c. Stroke
      - d. Polio
  - *B. Endocrine System
    - 1. Functional Organization

- a. Hypothalamus
- b. Pituitary Gland
- c. Thyroid Gland
- d. Parathyroid Glands
- e. Adrenal Glands
- f. Islets of Langerhans
- g. Gonads

2. Mechanisms
3. Malfunctions
   - a. Goiter
   - b. Diabetes

VI. Locomotion
   - A. Functional Organization
     - 1. Bones
     - 2. Cartilage
     - 3. Muscles
     - 4. Tendons
     - 5. Ligaments
   - B. Some Malfunctions Associated with Locomotion
     - 1. Arthritis
     - 2. Tendonitis

UNIT IV -- REPRODUCTION AND DEVELOPMENT

I. Asexual Reproduction
   - *A. Mitotic Cell Division
     - 1. Processes
       - a. Mitosis
       - b. Cytoplasmic Division
     - 2. Comparison Between Plant and Animal Mitotic Cell Division
     - 3. Uncontrolled Cell Division
   - B. Types of Asexual Reproduction
     - 1. Binary Fission
     - 2. Budding
     - 3. Sporulation
     - 4. Regeneration
     - 5. Vegetative Propagation

II. Sexual Reproduction
   - A. Reproduction and Development in Animals
     - 1. Gametogenesis
       - a. Meiosis
         - 1) Process
           - a) First Meiotic Division
           - b) Second Meiotic Division
         - 2) Comparison with Mitotic Cell Division
       - b. Spermatogenesis
       - c. Oogenesis
     - 2. Fertilization
       - a. External Fertilization
       - b. Internal Fertilization
     - 3. Embryonic Development
       - a. Process
         - 1) Cleavage
         - 2) Gastrulation
         - 3) Differentiation
         - 4) Growth
       - b. Site
         - 1) External Development
           - a) In Water
           - b) On Land
         - 2) Internal Development
           - a) Placental Mammals
           - b) Marsupials
     - 4. Reproduction and Development in Humans
       - a. Gametogenesis
         - 1) Male Reproductive System
         - 2) Female Reproductive System
           - a) Menstrual Cycle
           - b) Role of Hormones
       - b. Fertilization
       - c. Development
         - 1) Prenatal Development
         - 2) Birth
         - 3) Postnatal Development
   - B. Reproduction and Development in Flowering Plants

1. Flower Structure
2. Pollination
3. Fertilization and Embryo Development
4. Germination
5. Growth

UNIT V — TRANSMISSION OF TRAITS FROM GENERATION TO GENERATION

*I. Foundations of Genetics
    *A. Mendelian Principles
    B. Gene-Chromosome Theory

*II. Some Major Genetic Concepts
    *A. Dominance
    *B. Segregation and Recombination
    C. Intermediate Inheritance
    D. Independent Assortment
    E. Gene Linkage
    F. Crossing Over
    G. Multiple Alleles
    H. Sex Determination
    I. Sex Linkage

*III. Mutations
    *A. Types
        1. Chromosomal Alterations
            a. Change in Chromosome Number
            b. Change in Chromosome Structure
        2. Gene Mutations
    *B. Mutagenic Agents

IV. Genetic Applications to Animal and Plant Breeding

V. Interaction of Heredity and Environment

VI. Human Heredity
    A. Techniques for Detection
    B. Genetically Related Disorders
        1. Phenylketonuria (PKU)
        2. Sickle-Cell Anemia
        3. Tay-Sachs

*VII. Modern Genetics
    *A. DNA as the Heredity Material
        *1. DNA Structure
            a. DNA Nucleotide
            b. Watson-Crick Model
        2. DNA Replication
        3. Gene Control of Cellular Activities
            a. RNA
            b. Genetic Code
            c. Protein Synthesis
            d. The "One Gene-One Polypeptide Hypothesis"
            e. Individuality of Organisms as Related To Their DNA
            f. Gene Mutations
                1) Description
                2) Types
    B. Genetic Research
        1. Cloning
        2. Genetic Engineering
    *C. Population Genetics
        1. Population
        2. Gene Pool
        3. Gene Frequency
        4. The Hardy-Weinberg Principle

UNIT VI — EVOLUTION

I. Evolution

*II. Evolution Theory
    *A. Supporting Observations
        1. Geologic Record
        2. Comparative Cytology

3. Comparative Biochemistry
4. Comparative Anatomy
5. Comparative Embryology
*B. Theories of Evolution
1. Lamarck
2. Darwin
*3. Modern Evolutionary Theory
*a. Producing Variation
b. Natural Selection
1) Geographic Isolation
2) Reproductive Isolation
c. Time Frame for Evolution
1) Gradualism
2) Punctuated Equilibrium

*III. Heterotroph Hypothesis
A. Primitive Life Forms
1. Raw Materials
a. Matter
b. Energy Sources
2. Synthesis
3. Nutrition
4. Reproduction
B. Heterotroph to Autotroph
C. Anaerobe to Aerobe

UNIT VII — ECOLOGY

I. Ecology

II. Ecological Organization
A. Population
B. Community
C. Ecosystem
D. Biosphere

III. Ecosystems
A. Ecosystem Structure and Function
1. Components
*a. Abiotic Factors
b. Biotic Factors
1) Nutritional Relationships
a) Autotrophs
*b) Heterotrophs
(1) Saprophytes
(2) Herbivores
(3) Carnivores
(4) Omnivores
2) Symbiotic Relationships
a) Commensalism
b) Mutualism
c) Parasitism
2. Energy Flow Relationships
a. Energy Flow
b. Food Chain
c. Food Web
1) Producers
2) Consumers
3) Decomposers
d. Pyramid of Energy
e. Biomass Pyramid
3. Material Cycles
a. Carbon-Hydrogen-Oxygen Cycle
b. Water Cycle
c. Nitrogen Cycle
*B. Ecosystem Formation
*1. Succession
a. Pioneer Organisms
b. Changes
c. Climax Community
2. Competition
*3. Biomes
a. Terrestrial Biomes
1) Characteristics
2) Geographic Factors
b. Aquatic Biomes
1) Marine
2) Fresh Water

- *IV. Biosphere and Humans
  - *A. Past and Present
    - 1. Negative Aspects
      - a. Human Population Growth
      - b. Human Activities
        - 1) Overhunting
        - 2) Importation of Organisms
        - 3) Exploitation
        - 4) Poor Land Use Management
        - 5) Technological Oversight
          - a) Water Pollution
          - b) Air Pollution
          - c) Biocide Use
          - d) Disposal Problems
    - 2. Positive Aspects
      - a. Population Control
      - b. Conservation of Resources
      - c. Pollution Controls
      - d. Species Preservation
      - e. Biological Control
      - f. Laws
  - B. The Future

Unit I - Unity and Diversity Among Living Things

UNIT I — UNITY AND DIVERSITY AMONG LIVING THINGS

OBJECTIVES

The student should be able to:

- Define life in terms of the functions performed by living organisms.
- Describe some of the schemes by which organisms are classified.
- Recognize the role of the cell as the basic unit of structure and function of most living things.
- Identify major biochemical compounds and some of the metabolic reactions in which these compounds are involved.
- Identify the appropriate tools and/or techniques used for cell study.
- Recognize that a unity of pattern underlies the diversity of living things.

TOPICS	UNDERSTANDINGS	TEACHER NOTES
I. Concept of Life		
A. Definition	Scientists have been unable to agree upon a single definition of life. This syllabus characterizes life by the functions that living organisms perform.	
B. Life Functions		
1. Nutrition	Nutrition includes the activities of an organism by which it obtains materials from its environment and processes them for its use.	
2. Transport	Transport involves the absorption and distribution of materials within an organism.	
3. Respiration	Respiration includes those processes which provide the energy necessary for the maintenance of life functions.	

TOPICS	UNDERSTANDINGS	TEACHER NOTES
4. Excretion	Excretion involves the removal of cellular waste products.	
5. Synthesis	Synthesis involves those chemical activities by which large molecules are built from smaller ones.	
6. Regulation	Regulation involves the control and coordination of the various activities of an organism.	
7. Growth	Growth involves an increase in cell size and/or cell numbers. This process utilizes the products of synthesis.	
8. Reproduction	Reproduction involves the production of new individuals. Species survival is dependent upon reproduction.	
C. Metabolism	Metabolism is the total of all the life activities required to sustain life.	
D. Homeostasis	Life functions are carried out by an organism in an integrated manner that results in the maintenance of a stable internal environment. This maintenance is known as homeostasis.	
II. Diversity of Life		
A. Necessity for Classification	In order to study the unity and diversity of living organisms in an organized manner, biologists classify organisms.	
B. A Scheme of Classification	There is some disagreement as to the best classification system. In one modern system, organisms are grouped into five kingdoms. Each kingdom is divided into phyla. Phyla are categories which indicate major differences in structure among organisms. The classification system used in this syllabus utilizes five kingdoms: Monera, Protista, Fungi, Plant, and Animal.	

This five kingdom system is based on the following criteria:

1) The presence or absence of a nuclear membrane within the cell.
2) Unicellularity versus multicellularity.
3) Type of nutrition.

KINGDOMS:	CHARACTERISTICS:	EXAMPLES:
MONERA	Primitive cell structure lacking a nuclear membrane.	
Bacteria		
Blue-Green Algae		
PROTISTA	Predominately unicellular organisms with plant-like and/or animal-like characteristics.	
Protozoa	Animal-like in their mode of nutrition.	paramecium, ameba
Algae	Plant-like in their mode of nutrition.	spirogyra
FUNGI	Cells are usually organized into branched, multinucleated filaments which absorb digested food from their environment.	yeast, bread mold, mushroom

This chart is not a complete representation of the five kingdoms. Additional examples may be cited by the teacher.

The cells of monerans are prokaryotic.

The term multinucleated is used in place of multicellular since well-defined cell partitions are lacking.

KINGDOMS:	CHARACTERISTICS:	EXAMPLES:
PLANT	Multicellular, photosynthetic organisms.	
Bryophytes	Lack vascular tissue, therefore, no true roots, stems, or leaves.	moss
Tracheophytes	Possess vascular tissue, true roots, stems, and leaves.	geranium, fern, bean, pine tree, maple tree, corn
ANIMAL	Multicellular organisms that ingest their food.	
Coelenterates	Two cell layers, hollow body cavity.	hydra, jellyfish
Annelids	Segmented body walls.	earthworm, sandworm
Arthropods	Jointed appendages, exoskeleton.	grasshopper, lobster, spider
Chordates	Dorsal nerve cord.	shark, frog, human

This five-kingdom system of classification is predicated on the idea that monerans are the most primitive.

Most classification systems suggest relationships among organisms which may indicate common ancestry.

TOPICS	UNDERSTANDINGS	TEACHER NOTES
C. Nomenclature	The modern system of naming organisms is based upon binomial nomenclature devised by Linnaeus. In this system the first part of the organism's name, in Latin, is its genus, and the second part of the name, in Latin, indicates its species. A species is a group of organisms that are similar in structure and can mate and produce fertile offspring.	Students will be expected to understand the terms kingdom, phylum, genus, and species.
III. Unity of Life		
A. Structure of Living Organisms		
1. Cell Theory	Cells are the basic units of structure and function of living things. Cells come from preexisting cells.	
a. Historical Background	The improvement of the microscope and microscopic techniques throughout the last four centuries has allowed scientists to observe cells better and to develop the cell theory.	Scientists such as Leeuwenhoek, Hooke, Brown, Schleiden, Schwann, and Virchow contributed to the establishment of the cell theory.
b. Methods of Cell Study	Continuing advances in techniques and instrumentation have enabled biologists to increase their understanding of cell structures and functions.	
1) Instrumentation		

INSTRUMENTS	UNDERSTANDINGS
Compound light microscope	Parts, uses
Electron microscope	Advantages, limitations
Dissecting microscope	Examination of opaque objects
Ultracentrifuge	Separation of cell parts according to density
Microdissection instruments	Removal, addition, and/or transfer of individual cell organelles.

TOPICS	UNDERSTANDINGS	TEACHER NOTES
2) Measurement	The minute size of most cells requires the use of a small unit for measurement. This unit is known as the micrometer (um). One thousand micrometers is equal to one millimeter.	Micrometer is a term currently used to replace the term micron. Students should be able to make conversions between micrometers and millimeters.
3) Techniques	The development of staining techniques using such solutions as iodine and methylene blue has made possible a more detailed study of cell structures.	
c. Cell Organelles	In cells, various specialized functions occur in subcellular structures known as organelles. Some major organelles and their functions are:	The Fluid-Mosaic Model will be taught in Unit II, page 27.

ORGANELLE	FUNCTION
Plasma membrane (cell membrane)	Regulates the transport of certain materials into and out of the cell
Cytoplasm	A fluid-like environment between the nucleus and the plasma membrane in which other organelles are suspended and within which many biochemical processes occur
Nucleus	Surrounded by the nuclear membrane; genetic information contained within chromosomes directs the activities of the cell
Nucleolus	Involved with the synthesis of ribosomes

ORGANELLE	FUNCTION
Endoplasmic Reticulum	A series of interconnecting channels associated with storage, synthesis, and transport of substances within the cell
Ribosome	Site of protein synthesis May be free in the cytoplasm or attached to membranes
Mitochondrion	Site of cellular respiration
Golgi Complex	Synthesizes, packages, and secretes cellular products
Lysosome	Contains digestive enzymes
Vacuole	A space in a cell surrounded by a membrane which may contain water or other materials is a vacuole. Specialized vacuoles are present in unicellular organisms. Food vacuoles are digestive organelles and contractile vacuoles help maintain water balance.
Centriole	A cylindrical structure found in the cytoplasm which appears to function during the division of certain cells
Chloroplast	Pigment-containing structure which serves as a site for photosynthesis
Cell Wall	A nonliving structure which surrounds and supports a cell

Centrioles are common to animal cells and rare in plants.

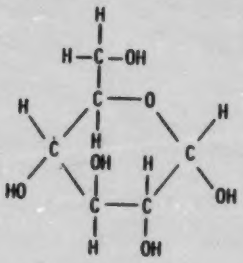
TOPICS	UNDERSTANDINGS	TEACHER NOTES
2. Exceptions to the Cell Theory	There are several exceptions to the cell theory: - The first cell could not have arisen from a previously existing cell. - Viruses are not composed of cells but do contain genetic material and can reproduce in the presence of a host cell. - Although considered organelles, mitochondria and chloroplasts contain genetic material and can reproduce in the presence of a cell.	
B. Chemistry of Living Organisms		
*1. Chemical Elements in Living Matter	The cell is a complex "chemical factory" composed of some of the same elements found in the nonliving environment. Of all the elements present in living matter, carbon, hydrogen, oxygen, and nitrogen are present in the greatest percentages. Some examples of elements found in smaller quantities are sulfur, phosphorus, magnesium, iodine, iron, calcium, sodium, chlorine, and potassium.	
*2. Chemical Compounds in Living Matter	Organisms consist of inorganic and organic compounds.	
a. Inorganic Compounds	Inorganic compounds are compounds that lack the combination of the elements carbon and hydrogen. The principal inorganic compounds in living things include water, salts, inorganic acids, and bases.	Students should be able to differentiate between ionic and covalent bonding.
b. Organic Compounds	Organic compounds are compounds which contain both the elements carbon and hydrogen. The major categories of organic compounds found in living things are carbohydrates, lipids, proteins, and nucleic acids.	

1) Carbohydrates

a) Composition

Carbohydrates consist of the elements carbon, hydrogen, and oxygen. Hydrogen and oxygen atoms are most often present in a 2:1 ratio. The basic unit of the carbohydrate is the monosaccharide. Glucose, $C_6H_{12}O_6$, is an example.

BC



Students will not be expected to produce structural formulas. They should, however, be able to recognize compounds when their structural formulas are shown.

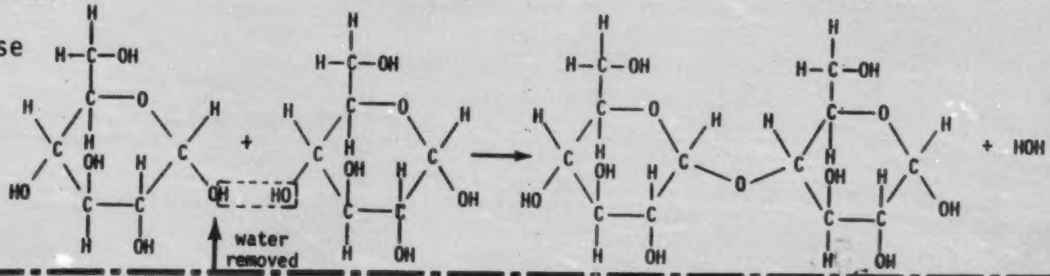
Two monosaccharides chemically combine as a result of dehydration synthesis and form a disaccharide. Maltose, $C_{12}H_{22}O_{11}$, is an example.

$$C_6H_{12}O_6 + C_6H_{12}O_6 \longrightarrow C_{12}H_{22}O_{11} + H_2O$$

Glucose + Glucose ⟶ Maltose + water

Hydrolysis as illustrated on pages 50-51 may be introduced at this time or may be reserved until page 24, or 50-51.

BC Formation of Maltose



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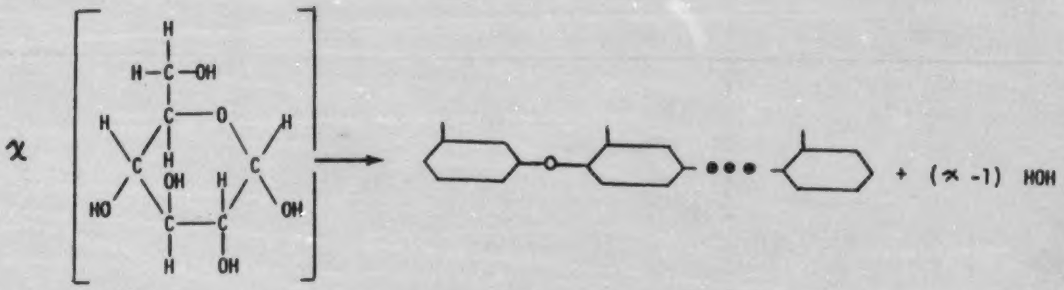
57

Many monosaccharides chemically combine by dehydration synthesis and form a polysaccharide such as starch.

BC Formation of a polysaccharide



b) Examples

Carbohydrates include all sugars and starches. Examples of simple sugars include glucose, fructose, and ribose. Examples of disaccharides include maltose and sucrose. The names of sugars end in ose. Examples of polysaccharides include starches, cellulose, and glycogen.

c) Functions

In organisms, carbohydrates are used primarily as sources of energy, and also as components of cell structures such as the cell wall.

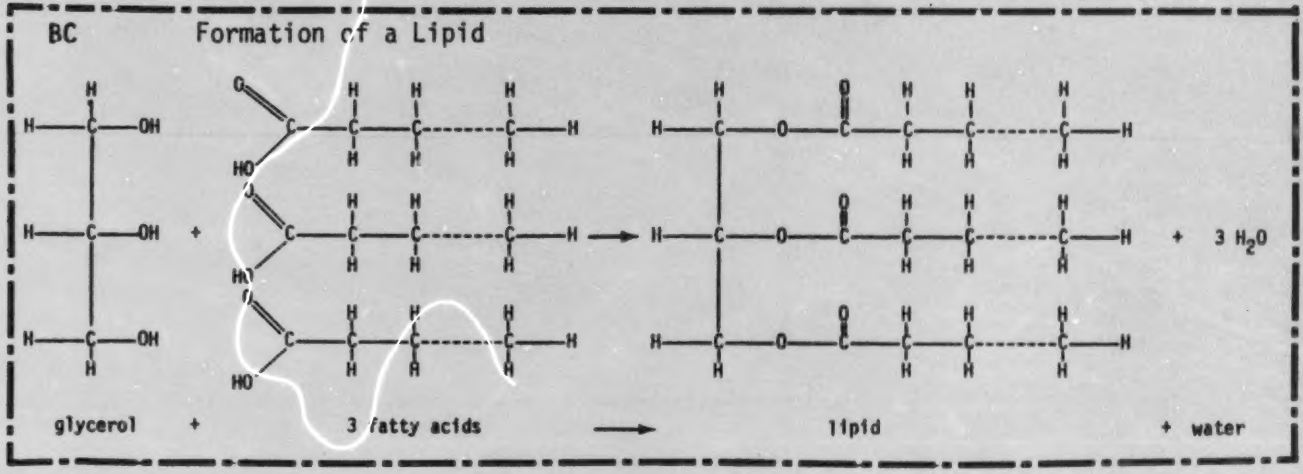
2) Lipids

a) Composition

Lipids, like carbohydrates, contain carbon, hydrogen, and oxygen. However, the ratio of hydrogen to oxygen is much greater than 2:1, and is not constant from one lipid to another.

Some lipids are the product of the dehydration synthesis of three molecules of fatty acids and one molecule of glycerol.

3 fatty acids + glycerol ⟶ lipid + 3 water


BC
Formation of a Lipid
glycerol
+
3 fatty acids
lipid
+ water
+ 3 H_2O

b) Examples — Lipids include fats and oils.

c) Functions — Lipids are used primarily as sources of stored energy and also as components of cell structures such as cell membranes.

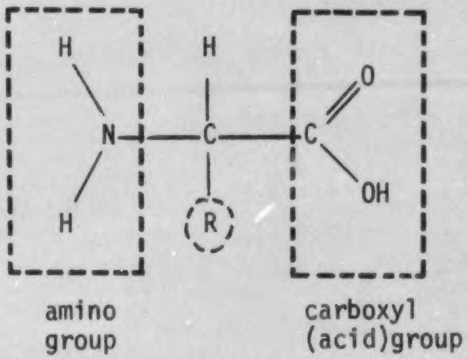
3) Proteins

a) Composition — Proteins contain carbon, hydrogen, oxygen, nitrogen, and, in many instances, sulfur.

A protein is composed of building blocks known as amino acids.

Twenty amino acids are usually found in living systems.

BC Generalized Structure of an Amino Acid

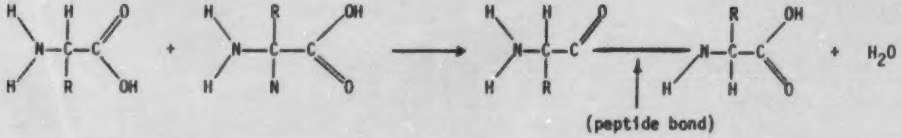

H
H
N
C
H
R
C
O
OH
amino group
carboxyl (acid)group

(R) represents a variable group and is the basis for the variety of amino acids.

Two amino acid units can be chemically combined by dehydration synthesis and form a dipeptide.

Amino acid + amino acid → dipeptide + water

BC Formation of a Dipeptide


+
→
+ H_2O
(peptide bond)

Some proteins contain special amino acids that supplement the basic set of 20 amino acids.
All the special amino acids are formed by modification of a common amino acid.

TOPICS	UNDERSTANDINGS	TEACHER NOTES
	Polypeptides result from the dehydration synthesis of many amino acids. A protein is usually composed of one or more polypeptide chains. There is an extremely large number of different proteins. The bases for variability include differences in the number, kinds, and sequence of amino acids present.	
b) Examples	Proteins include insulin, hemoglobin, and enzymes.	
c) Functions	Proteins are components of cell structures and enzymes.	Nucleic Acids are treated in Unit V.
*3. Chemical Control	Living matter is in a state of dynamic chemical activity. Perhaps the most significant distinction between living and nonliving matter is the continuous and controlled chemical activity present in living systems.	
a. The Role of Enzymes	Enzymes are organic catalysts that are the principal regulators of most chemical activity in living systems. - Each chemical reaction occurring in an organism requires a specific enzyme. - Enzymes modify the rate of reactions.	
1) Structure	Enzymes are large complex proteins consisting of one or more polypeptide chains whose names end in ase.	
a) Protein Nature	All enzymes are either exclusively proteins or are proteins with non-protein parts known as coenzymes. Often, vitamins function as coenzymes.	
b) Active Site	Usually enzyme molecules are much larger than the molecules with which they interact. The specific way in which these chains fold results in the formation of pockets into which reacting molecules fit. This specific area of the enzyme is the active site.	

TOPICS	UNDERSTANDINGS	TEACHER NOTES
2) Function	Evidence has accumulated to permit biochemists to develop a model of enzyme action which is useful in visualizing the nature of its function and which is consistent with the available evidence.	
a) Enzyme-Substrate Complex	It is thought that, for an enzyme to affect the rate of a reaction, the following events take place. - The enzyme must form a temporary association with the substance or substances whose reaction rate it affects. These substances are known as substrates. - This association between enzyme and substrate is thought to involve a close physical association between the molecules and is called the enzyme-substrate complex. - While the enzyme-substrate complex is formed, the enzyme action takes place. - Upon completion of the reaction, the enzyme and product(s) separate. The enzyme molecule is now available to form additional complexes. Although enzymes may be reused in cells, they eventually are destroyed and new ones must be synthesized.	
b) "Lock and Key" Model	The inference that a particular enzyme molecule will only interact with a single type of substrate has given rise to the "lock and key" model of enzyme specificity. Like a key that will open only a particular lock, a particular enzyme will usually only form a complex with one particular type of substrate.	
b. Factors Influencing Action of Enzymes	The rate of enzyme action is not fixed, but varies according to the environmental conditions of the reacting substances. Such factors as pH, temperature, and relative amounts of enzyme and substrate can determine the rate of enzyme action.	

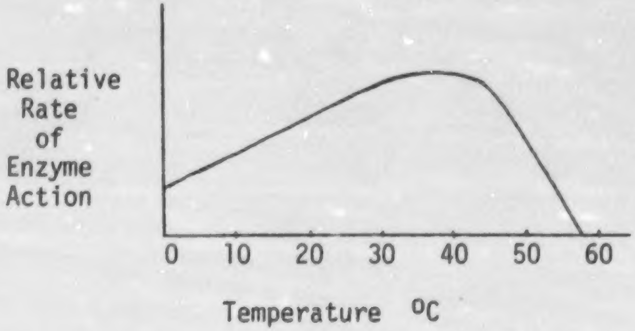
BC

1) Temperature

In general, as temperature increases, the rate of enzyme action increases. The temperature at which an enzyme is most efficient is the optimum temperature.

At relatively high temperatures, however, the shape of enzyme molecules tends to be altered, thus rendering the enzyme ineffective. This distortion of enzyme molecules at high temperatures is enzyme denaturation. For many enzymes in the human body, denaturation begins to occur at around 40°C.

The response to changing temperature for many enzymes of humans is illustrated in the graph below:



2) Relative Amounts of Enzyme and Substrate

The rate of enzyme action also varies according to the amount of available substrate molecules. When an excess of substrate is added to a system with a fixed concentration of enzymes, the rate of enzyme action tends to increase to a point and then remain fixed as long as the enzyme concentration remains constant.

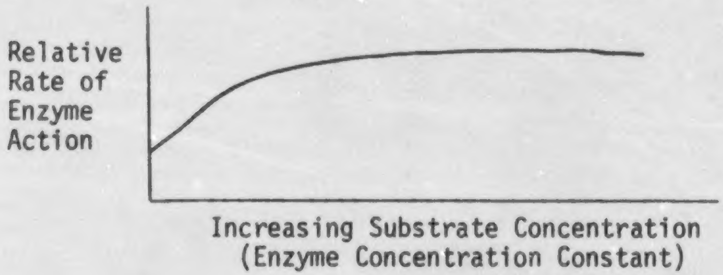
TOPICS

UNDERSTANDINGS

TEACHER NOTES

BC continued

The graphs below illustrate the pattern of enzyme action rates when an excess of substrate is added to a system with a fixed enzyme concentration:



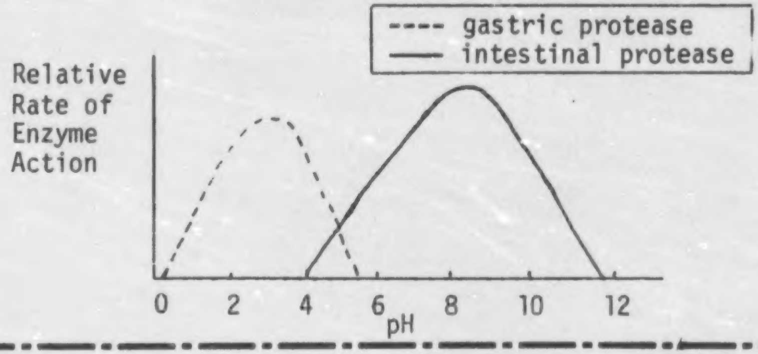
3) pH

The rate at which enzyme-regulated reactions occur varies according to the pH of the environment.

- The pH scale indicates the hydrogen ion (H^+) concentration.
- The pH scale extends from 0 - 14. A pH of 7 indicates a neutral condition. Acids have a pH of less than 7 and bases have a pH greater than 7.

For many enzyme-controlled reactions, a pH of 7 provides the optimum environment.

Other enzymes work best within different pH ranges. Specific pH ranges of enzymes are illustrated below:



Students are not responsible for the pH range of specific enzymes but should be able to graph and interpret data.

Unit II - Maintenance in Living Things

UNIT II — MAINTENANCE IN LIVING THINGS

Among living organisms there is a universality of the functions which maintain life. These include the obtaining, processing, and distribution of essential materials, the removal of metabolic wastes, and the regulation of all metabolic processes.

While these functions are universal, organisms possess various structures and behavioral patterns which enable them to perform these functions efficiently in their environment. These structures and/or patterns are known as adaptations.

OBJECTIVES

The student should be able to:

- Identify and describe the basic functions necessary to maintain homeostasis.
- Identify and compare the adaptations of selected organisms for carrying out these life functions.
- Recognize that a unity of pattern underlies the diversity of living things.
- Correlate biochemical reactions with physiological functions.
- Observe and recognize that structure and function complement each other and culminate in an organism's successful adaptation to its environment.

TOPICS	UNDERSTANDINGS	TEACHER NOTES
*I. Nutrition	Nutrition includes those activities by which organisms obtain and process materials needed for energy, growth, repair, and regulation. Two types of nutrition are autotrophic and heterotrophic.	
A. Autotrophic Nutrition	The ability of most plants and certain monerans and protists to manufacture organic compounds from inorganic raw materials is autotrophic nutrition.	A second mode of autotophic nutrition is chemosynthesis. An awareness of this process may facilitate understanding of the nitrogen cycle in Unit VII.

TOPICS	UNDERSTANDINGS	TEACHER NOTES
1. Process of Photosynthesis	Photosynthesis, the process during which light energy is converted into the chemical energy of organic molecules, is one type of autotrophic nutrition.	
a. Significance	Most of the chemical energy available to organisms results from photosynthetic activity. Photosynthesis is the source of most of the oxygen in the air.	
b. Process	Most cells which carry on photosynthesis contain chloroplasts. These chloroplasts contain pigments which include chlorophylls. The variety of pigments contained within the chloroplasts can be separated by a technique called chromatography. In the chloroplasts, CO_2 and H_2O are used in the formation of simple sugar molecules and oxygen. Light energy is trapped by chlorophyll and converted into the chemical energy of simple sugar molecules. Red and blue wavelengths of light are most effective for this energy conversion because of their relatively high degree of absorption by chlorophyll molecules. Wavelengths of green light are less effective than red or blue. Simplified summary statements for photosynthesis are: $\text{carbon dioxide} + \text{water} \xrightarrow[\text{Chlorophyll Enzymes}]{\text{Light Energy}} \text{glucose} + \text{water} + \text{oxygen}$ $6\ CO_2 + 12H_2O \xrightarrow[\text{Chlorophyll Enzymes}]{\text{Light Energy}} C_6H_{12}O_6 + 6H_2O + 6O_2$	

BC

In photosynthesis, two major sets of reactions occur: light and dark reactions. The use of various isotopes has led to a greater understanding of these reactions.

Photochemical (light) reactions - These reactions occur within layered membranes inside the chloroplasts. Stacks of these membranes, the grana, contain the enzymes and the pigments necessary for the light reactions. Some of the energy absorbed by the chlorophyll pigments is used to "split" water molecules, producing hydrogen atoms and oxygen gas. This process is photolysis. The use of the isotope oxygen-18 has shown that all of the oxygen liberated during photosynthesis is from water molecules. An energy transfer compound, ATP, is produced within the chloroplasts during the light reactions. Details of this phase are still under investigation.

ATP will be discussed in more detail on page 32.

Carbon-Fixation (dark) reactions - These reactions occur within the chloroplasts in the stroma. The stroma is the dense solution outside the grana. Enzymes necessary for the dark reactions are found in the stroma. Hydrogen atoms from the light reaction and the carbon dioxide molecules participate in a series of chemical changes which produce a three-carbon sugar (PGAL) from which other molecules, including glucose, are synthesized. The isotope carbon-14 has been used to trace the pathways of carbon fixation.

c. Results

The glucose which is formed may be:
1) Used as an energy source in cellular respiration.
2) Synthesized into other metabolic compounds.
3) Converted into storage products by dehydration synthesis and other reactions.

a) Before these storage products can be used they are converted into simpler molecules by digestion within the cells (intracellular digestion), rather than in a specialized digestive system.

b) Once digestion is completed, the end products can be used in the cell or they can be transported to other tissues.

2. Adaptations for Photosynthesis

Algae and green plants are autotrophic organisms which carry on photosynthesis.

A large percentage of photosynthesis is carried on by unicellular algae present in the oceans. In these organisms, raw materials necessary for photosynthesis are absorbed directly into the individual cells.

Most terrestrial plants have specialized organs adapted for photosynthesis. Although photosynthesis may occur in the stems of some plants, the organs which are most highly adapted for this process are the leaves.

- Most leaves provide a large surface area for the absorption of light energy.
- The chief functions of the outer cell layers of the leaf (epidermis) and the waxy covering of the epidermis (cuticle) are: the protection of the internal tissues of the leaf from excessive water loss, resistance to invasion by fungi, and protection from mechanical injury.
- Openings in the cuticle and epidermis are called stomates. Their size is regulated by guard cells. Stomates allow the exchange of O_2, CO_2, and H_2O between the external environment and internal air spaces.
- Most photosynthesis occurring in leaves takes place in the palisade layer which is located under the upper epidermis.

TOPICS	UNDERSTANDINGS	TEACHER NOTES
	- The spongy layer contains many interconnected air spaces which are surrounded by moist surfaces. The exchange and circulation of gases occur here. The spongy layer also carries on photosynthesis. - In most leaves, chloroplasts are present in the palisade and spongy layers and in the guard cells. - Conducting tissue, located in the veins of the leaves, carries water to the photosynthesizing cells and distributes food to other plant organs.	
B. Heterotrophic Nutrition	Organisms unable to make organic molecules from inorganic raw materials are heterotrophs. Examples of groups of heterotrophic organisms include bacteria, fungi, protozoans, and animals.	
1. Processes for Heterotrophic Nutrition	Heterotrophic organisms obtain preformed organic molecules from their environment.	
a. Ingestion	Ingestion is the process of taking in food.	
b. Digestion	Digestion is the conversion of large, insoluble molecules to smaller soluble molecules. Digestion can be intracellular or it can be extracellular followed by the absorption of end-products.	
1) Mechanical Breakdown	Food is mechanically broken down by physical means, such as cutting, grinding, and tearing which increases the surface area of the foods prior to chemical digestion.	
2) Chemical Digestion	Large organic molecules are changed chemically to smaller organic molecules by enzymatic hydrolysis.	Hydrolysis, as illustrated on pages 50-51, may be introduced at this time.
	Complete digestion of large molecules produces end products as indicated:	

Large Molecules	End Products
carbohydrates	simple sugars
lipids	fatty acids and glycerol
proteins	amino acids

The end products of chemical digestion are the same in all organisms.

c. Egestion

Egestion is the removal (elimination) of undigested or indigestible material by the heterotrophic organism.

Heterotrophs may not be able to digest all food components either because they may lack specific enzymes, or because the time that food is exposed to available enzymes may be too short.

2. Adaptations for Heterotrophic Nutrition

a. Fungi

Fungi live on or in their food supply. The filamentous body of a fungus, such as bread mold, contains special filaments called rhizoids which penetrate the food source and secrete digestive enzymes. This results in extracellular digestion and the subsequent absorption of digested nutrients.

b. Protozoans

In the ameba, food is ingested by means of pseudopods. This engulfing process is phagocytosis.

In the paramecium, as a result of the action of cilia, food is ingested through a fixed opening located in the oral groove.

Intracellular digestion of this food occurs within a food vacuole after it merges with a lysosome. The end products of the digestion are then absorbed into the cytoplasm.

TOPICS	UNDERSTANDINGS	TEACHER NOTES
	In the paramecium, undigested materials are egested through a fixed opening called the anal pore.	
c. Animals		
1) Hydra	The hydra has a sac-like digestive cavity with a single opening. Food is ingested through this opening with the aid of tentacles and passes into the digestive cavity. In the digestive cavity, extracellular digestion occurs as a result of enzymes which are secreted by specialized cells located in the lining of the cavity. Partially digested food is then engulfed by phagocytic cells lining the cavity and digestion is completed intracellularly. Undigested material is egested through the same opening through which ingestion occurred.	
2) Earthworm	A tube-like digestive system with two openings is present. This one-way digestive tract allows food to be processed in an efficient manner as it passes through specialized organs. Food is ingested through the mouth, passes through the esophagus into the crop,where it is temporarily stored, and then into the gizzard where mechanical breakdown occurs. From the gizzard, the food passes into the intestine where most chemical digestion takes place and where end products are absorbed into the circulatory system. Undigested material is egested through the anus.	
3) Grasshopper	In the grasshopper, the structure and function of the digestive system are essentially similar to that of the earthworm. Food moves in one direction from mouth to anus.	

TOPICS	UNDERSTANDINGS	TEACHER NOTES
	The grasshopper possesses highly specialized mouth parts for mechanical breakdown. Salivary glands and gastric caeca secrete hydrolytic enzymes into the digestive tract for chemical digestion.	
4) Human	The digestive system is essentially similar to that of the grasshopper and earthworm in that it contains: - A tube-like system with two openings - Specialized organs and glands for mechanical breakdown and chemical digestion.	Humans are included here as another representative organism. The detailed study of human physiology is reserved for Unit III.
*II. Transport	The process of transport involves the absorption and circulation of materials throughout an organism.	
*A. Process		
1. Absorption	Absorption is the process whereby the end products of digestion, as well as other dissolved solids and gases, enter the fluids and the cells of an organism.	
a. Structure of the Cell Membrane	The cell membrane selectively regulates the entry and exit of materials. This aids cells in maintaining homeostasis.	
	A currently accepted model of the cell membrane is the fluid-mosaic model. This model suggests that the membrane is a double lipid layer in which large proteins float. Many small particles, such as molecules, diffuse through the membrane. Most larger molecules such as proteins and starches cannot diffuse into or out of cells unless they are chemically digested. The size of the molecule does not seem to be the sole determining factor in all cases.	In 1972, S. J. Singer proposed a model for the cell membrane that has become widely accepted. This model shows a double phospholipid layer positioned with the hydrophobic tails away from the membrane surface and the hydrophilic heads toward the outer and inner membrane surfaces. This

TOPICS	UNDERSTANDINGS	TEACHER NOTES
		is similar to the Danielli model. However, in Singer's Fluid-Mosaic Model, the proteins are not limited to the surfaces of the membrane but rather are embedded in the lipid layers like "floating icebergs in a fatty sea."
b. Function of the Cell Membrane	The cell membrane has both passive and active roles in transporting materials into and out of cells.	
1) Passive Transport	In passive transport the movement of the materials through the cell membrane is the result of the kinetic energy of the particles in motion. Diffusion, a form of passive transport, is a process in which the net movement of ions or soluble molecules is from a region of higher concentration to a region of lower concentration. The diffusion of water through a membrane is osmosis.	
2) Active Transport	Active transport is a process in which cellular energy is used to move particles through a membrane. This movement is from a region of low concentration toward a region of high concentration. Carrier proteins embedded in the cell membrane aid the transport of materials.	
3) Pinocytosis	Pinocytosis is a process whereby vacuoles formed at the cell surface bring in large dissolved molecules.	
4) Phagocytosis	Phagocytosis is a process in which a cell engulfs undissolved large particles by flowing around them and enclosing them in a vacuole.	

TOPICS	UNDERSTANDINGS	TEACHER NOTES
*2. Circulation	The transport of materials within cells and/or throughout multicellular organisms is circulation.	
	Intracellular circulation is accomplished by diffusion, cyclosis, and possibly, by movement throughout the endoplasmic reticulum.	
	Intercellular circulation may be by diffusion or by transport through vascular tissue.	
*B. Adaptations	Intracellular circulation occurs within all living cells.	
	Intercellular circulation varies with the complexity of the organism.	
1. Plants	Simple multicellular plants, bryophytes, lack vascular tissue. Intercellular transport is accomplished by diffusion.	
	Higher plants, tracheophytes, possess vascular tissue for intercellular transport.	
a. Roots	Roots are structures specialized for anchorage, nutrient storage, absorption of water and soluble salts and for the conduction of materials to the stem.	
1) Root Hairs	Root hairs are elongated epidermal cells which increase the surface area of the root for the absorption of water and minerals.	
	The movement of materials through the semipermeable membrane of root hairs involves both diffusion, including osmosis, and active transport.	
2) Xylem	The xylem is specialized transport tissue extending from the roots to the leaves. The principal function of the xylem tissue is the conduction of water and minerals upward in the plant.	

TOPICS	UNDERSTANDINGS	TEACHER NOTES
	The mechanism by which water is transported through the xylem is best explained by the hypothesis of transpirational pull. Transpirational pull involves the transpiration of water vapor through the stomates. This exerts a pulling force on the column of water in the xylem. Because of the cohesive and adhesive properties of water, the water column does not break and is drawn up from the roots.	Under conditions of high humidity, root pressure may play a role in pushing water up through the xylem of small plants.
3) Phloem	Phloem conducts organic food materials both upward and downward to plant tissues for immediate use or storage.	
b. Stems	Although the structure of the stem is different from that of the roots, the vascular tissues are continuous.	
c. Leaves	Leaves contain veins which are extensions of the conducting tissues in the stem.	
2. Animals		
a. Hydra	Since most of its cells are in direct contact with a watery environment, the hydra is able to survive without a special transport system. Flagellated cells aid in the circulation of materials throughout the gastrovascular cavity. Intercellular circulation is by diffusion.	

TOPICS	UNDERSTANDINGS	TEACHER NOTES
b. Earthworm	Many cells of the earthworm are not in direct contact with the external environment. An internal, closed circulatory system where blood is contained within vessels transports materials throughout the organism. The hemoglobin dissolved in the blood distributes respiratory gases between the external environment and the cells. Water and dissolved materials, including the end products of digestion, are transported from the digestive system to the cells of the organism. Aortic arches pump the blood within the blood vessels. An infolding of the earthworm's digestive tube is an adaptation which increases the absorptive surface through which digestive end products enter the blood.	
c. Grasshopper	The grasshopper has an internal, open, circulatory system which brings materials in contact with all cells. In contrast to a closed circulatory system, in an open system, blood is distributed into sinuses by means of a pulsating blood vessel. As in the earthworm, the grasshopper has an infolded digestive tube which increases the absorption area.	
d. Human	The human circulatory system is a closed system with hemoglobin for oxygen transport. There is a pumping structure called the heart. Infoldings of the digestive tube increase the absorption area for nutrients.	

TOPICS	UNDERSTANDINGS	TEACHER NOTES
III. Respiration	Respiration is a process that occurs continuously in the cells of all organisms.	
	It involves the transfer of the stored chemical energy in food molecules to a form readily usable by organisms. It usually also involves an exchange of gases between the organism and its environment.	
A. Process		
1. Cellular	Cellular respiration refers to those enzyme-controlled reactions in which the potential energy of organic molecules, such as glucose, is transferred to a more available form of energy. This available form of energy is stored in adenosine triphosphate molecules. When ATP is hydrolyzed, energy is released and ADP is formed. This reaction is reversible. This energy can be used for metabolic activities which require energy. $H_2O + ATP \xrightleftharpoons{\text{ATP-ase}} ADP + P + \text{Energy}$	
	If the energy transfer reactions involve the use of molecular oxygen, the process is aerobic respiration. The majority of organisms carry on aerobic respiration. If free oxygen is not used, the process is anaerobic respiration.	
a. Anaerobic Respiration (Fermentation)	Some cells lack the enzymes necessary for aerobic respiration and other cells revert to anaerobic respiration when oxygen is lacking. The enzymes for anaerobic respiration are located in the cytoplasm of cells.	

1) Description

During most types of anaerobic respiration, glucose is gradually broken down in a series of enzyme-controlled reactions to either lactic acid or alcohol and CO_2. The end products vary depending on the type of organism. Lactic acid is produced in animals and is associated with muscle fatigue. Lactic acid is also produced by some bacteria and is important in the production of cheeses, buttermilk, and yogurt. Alcohol and CO_2 are usually produced by yeast and bacteria. These end products are useful in the baking and brewing industries.

As a result of anaerobic respiration there is a net gain of 2 ATP.

$$\text{Glucose} \xrightarrow{\text{enzymes}} \text{2 lactic acid} + \text{2 ATP}$$

$$\text{Glucose} \xrightarrow{\text{enzymes}} \text{2 alcohol} + 2CO_2 + \text{2 ATP}$$

The end products, lactic acid and/or alcohol, still contain a great deal of potential energy.

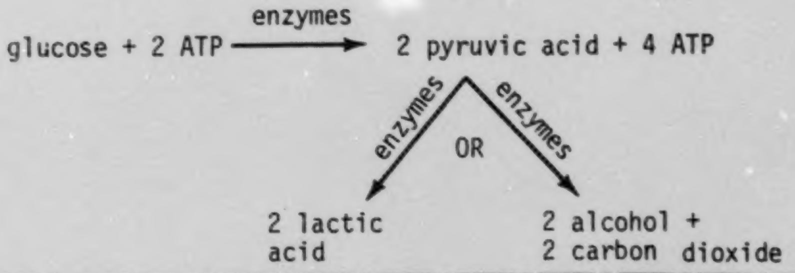
BC

2) Chemical Aspects

The first series of reactions in anaerobic respiration involves the conversion of glucose to pyruvic acid.

The conversion of pyruvic acid to either lactic acid or alcohol and CO_2 occurs without any further yield of energy.

The reactions of anaerobic respiration may be summarized as follows:



b. Aerobic Respiration

Many of the enzymes involved in aerobic cellular respiration are located in the mitochondria.

1) Description

During this process, and due to the presence of oxygen, the chemical energy of glucose is released gradually in a series of enzyme-controlled reactions.

The summary equation for aerobic respiration of glucose is:

$$\text{glucose} + \text{oxygen} \xrightarrow{\text{enzymes}} \text{water} + \text{carbon dioxide} + \text{ATP}$$

$$C_6H_{12}O_6 + 6\ O_2 \xrightarrow{\text{enzymes}} 6\ H_2O + 6\ CO_2 + 36^{*}\ \text{ATPs}$$

Aerobic respiration is more efficient than anaerobic.

*Authorities now believe that 38 ATPs are produced per molecule of glucose in all prokaryotic organisms, but that 36 ATPs are produced by respiration in eukaryotic organisms.

BC

2) Chemical Aspects

Investigations of the chemical reactions occurring during glucose oxidation indicate that, although there are many enzyme-catalyzed steps, there are two basic phases: the anaerobic and the aerobic.

Anaerobic phase: Glucose is oxidized to two molecules of pyruvic acid and the energy released is used to synthesize four molecules of ATP. Since the energy of two ATP molecules is required to activate this phase, there is a net gain of two ATPs.

Aerobic phase: The pyruvic acid molecules are oxidized and the energy released. Thirty-four ATP molecules are synthesized during this phase. Oxygen acts as a hydrogen acceptor, resulting in the formation of water. Carbon dioxide molecules are produced as a result of some intermediate reactions.

The net gain in the complete breakdown of one glucose molecule in aerobic respiration is therefore 36* ATPs.

*See previous note.

The relationship between the anaerobic and aerobic phases of cellular respiration are summarized below:

$$\text{glucose} + 2\ \text{ATP} \xrightarrow{\text{enzymes}} 2\ \text{pyruvic acid} + 4\ \text{ATP} \;\Big|\; 2\ \text{pyruvic acid} + \text{oxygen} \xrightarrow{\text{enzymes}} \text{carbon dioxide} + \text{water} + 34\ \text{ATP}$$

|—— anaerobic phase ——|—— aerobic phase ——|

AEROBIC CELLULAR RESPIRATION

TOPICS	UNDERSTANDINGS	TEACHER NOTES
2. Gas Exchange	Gas exchange involves the diffusion of gases between the organism and its environment.	
B. Adaptations	While the chemical processes of respiration are similar in most organisms, various adaptations for the exchange of respiratory gases are present in living things.	
1. Monera, Protista, and Fungi	In these organisms, gas exchange occurs by diffusion through thin, moist membranes. This gas exchange surface is an external surface.	
2. Plants	Plants have various methods for gas exchange.	
a. Leaves	The outer covering is dry and impermeable and not a gas exchange surface. Gas exchange occurs across the membranes of internal cells. These cells are bounded by moist intercellular spaces. Access to these spaces is through the stomates.	
b. Stems	Stems of woody plants contain lenticels which permit the exchange of gases.	Lenticels are small areas of loosely exposed cells.
c. Roots	Gas exchange occurs across the moist membranes of root hairs and other epidermal cells.	
3. Animals		
a. Hydra	Each cell of the hydra is in contact with the watery environment and gas exchange occurs by diffusion.	
b. Earthworm	As a terrestrial organism, the problem of the retention of a moist gas exchange surface is solved by the secretion of mucus by the skin. This maintains a moist surface which facilitates the diffusion of gases into and out of the blood. Hemoglobin aids in the transport of oxygen to the body cells.	

c. Grasshopper

Since the grasshopper possesses an open circulatory system lacking hemoglobin, gas transport and gas exchange are accomplished by tracheal tubes. The tracheal tubes terminate internally in moist membranes where gases are exchanged. The external body surface is dry and impermeable. Access to the tracheal tubes is through spiracles.

d. Human

Human skin is impermeable to respiratory gases. The lungs are a thin, moist, internal gas exchange surface. Hemoglobin aids in the transport of oxygen.

*IV. Excretion

*A. Process

The removal of cellular waste products of an organism is excretion.

1. Products

The metabolic activities of living organisms result in the production of waste materials.

Metabolic Activity	Wastes
Respiration	Carbon dioxide + water
Dehydration synthesis	Water
Certain metabolic processes	Mineral salts
Protein metabolism	Nitrogenous wastes

Nitrogenous wastes are produced when excess amino acids are utilized in cellular respiration.

Nitrogenous wastes vary from the extremely toxic ammonia to the less toxic urea and the nontoxic uric acid.

2. Results

Wastes may be either toxic or nontoxic. When toxic wastes are produced they are normally released, as in animals, or sealed off and stored, as in plants. Nontoxic wastes may either be retained, released, or recycled in other metabolic activities.

TOPICS	UNDERSTANDINGS	TEACHER NOTES
B. Adaptations	Organisms display various adaptations for excretion. Adaptations vary depending on the metabolic activities of the organism and the environment in which it lives.	
1. Protista	Special excretory structures are absent in many unicellular organisms. Excretion is accomplished by diffusion through cell membranes.	
a. Freshwater Protozoans	In the ameba and paramecium, carbon dioxide, ammonia, and mineral salts diffuse through the cell membrane directly into the watery environment.	The contractile vacuole functions in osmoregulation in freshwater protozoans.
b. Algae	The waste product of respiration, carbon dioxide, can be recycled in the photosynthetic process.	
	Some of the oxygen produced during photosynthesis is recycled for respiration.	
2. Plants	Plants recycle the photosynthetic and respiratory gases.	
	Excess gases leave the plant through the stomates, lenticels, and epidermal cells of the root.	
	Some waste products, such as organic acids which might be toxic, are stored in vacuoles where they cause no injury to the plant.	
3. Animals		
a. Hydra	Excretion in the hydra is essentially similar to that of the protozoans.	

TOPICS	UNDERSTANDINGS	TEACHER NOTES
b. Earthworm	Carbon dioxide is excreted by diffusion through the moist skin of the earthworm.	
	Pairs of excretory organs called nephridia located in most body segments of the earthworm excrete water, mineral salts, and urea into the terrestrial environment.	
c. Grasshopper	Carbon dioxide diffuses from the grasshopper's body fluids into tracheal tubes and is expelled through spiracles.	
	Water, mineral salts, and insoluble uric acid crystals accumulate in the Malpighian tubules and are transported to the digestive tube where most of the water is reabsorbed. Minerals and uric acid are expelled with the fecal material.	
	The excretion of uric acid is a water-conserving mechanism of particular advantage to an egg-laying terrestrial organism.	Uric acid is insoluble and can be stored in the egg without exerting harmful toxic or osmotic effects.
d. Human	CO_2 and H_2O are excreted through the respiratory system.	
	Humans possess nephrons, excretory structures similar to the nephridia of earthworms, for the excretion of water, salt, and urea.	
V. Regulation	Regulation is the coordination and control of the life activities. Coordination of all life functions depends on special control mechanisms. These mechanisms include nerve control (found in multicellular animals) and chemical control (common to all organisms).	

TOPICS	UNDERSTANDINGS	TEACHER NOTES
A. Nerve Control	Nerve control depends mainly on the functioning of the neurons (nerve cells).	
1. Functional Definitions		
a. Stimulus	A change in the external or internal environment which initiates an impulse	
b. Receptors	Structures specialized to detect certain stimuli	
c. Impulse	An electro-chemical charge generated along a neuron	
d. Response	A reaction to a stimulus	
e. Effectors	Organs of response such as muscles or glands	
f. Neuron	The nerve cell is a cell specially adapted for the transmission of impulses. It is composed of:	
1) Dendrites	Fibers which detect the stimulus and generate impulses toward the cyton	
2) Cyton	Cell body containing the nucleus	
3) Axon	A fiber that transmits the impulse away from the cyton toward the terminal branches, and	
4) Terminal Branches	Ends of the axons which secrete neurotransmitters.	
g. Synapse	Junction between adjacent neurons or between neuron and effector	
h. Neurotransmitters	Chemicals, such as acetylcholine, which, when secreted, aid in the transmission across the synapse	

TOPICS	UNDERSTANDINGS	TEACHER NOTES
2. Adaptations in Animals		
a. Hydra	The hydra possesses a nerve net composed of modified neurons. There is no central nervous system and impulses may travel in either direction over the neuron.	
b. Earthworm	The nervous system of the earthworm consists of a primitive brain composed of fused ganglia, a ventral nerve cord, and peripheral nerves. The presence of this central nervous system permits impulses to travel over definite pathways from receptors to effectors.	
c. Grasshopper	The grasshopper's nervous system is similar to that of the earthworm. The grasshopper possesses sensory organs which include eyes, tympana, and antennae.	
d. Human	The human central nervous system consists of a highly developed brain and dorsal nerve cord which permit impulses to travel over definite pathways. There are also many highly developed receptors.	
B. Chemical Control	Similar to nerve control, chemical control coordinates body processes by transmitting messages from one part of the organism to another. Unlike nerve control, chemical control is achieved through hormonal action in both plants and animals.	
1. Chemical Control in Plants		
a. Characteristics of Plant Hormones	Plant hormones are chemicals produced by cells which affect the growth and development of other cells.	

TOPICS	UNDERSTANDINGS	TEACHER NOTES
	Plant hormones function in the coordination of processes such as growth, tropisms, and reproduction.	
	There are no plant organs specialized exclusively for hormone production.	
	Plant hormone production is most abundant in actively growing areas such as the cells at the tips of roots and stems, buds, and seeds.	
b. Role of Plant Hormones	Auxins are one type of plant hormone.	
	Auxins influence division, elongation, and differentiation of plant cells.	
	Unequal distribution of auxins causes unequal growth responses called tropisms.	
	Unequal auxin distribution can be caused by external stimuli such as light and gravity.	
	Tropisms are usually adaptive growth responses that enhance the survival of the plant.	
	Hormones promote other developmental changes including flowering, fruit formation, and seed development.	
	Hormone responses depend upon the hormones involved, their concentrations, and the tissues affected.	
2. Chemical Control in Animals	Chemical control in animals differs from that in plants since animals possess cells specialized solely for hormone production.	
a. Endocrine Control	Endocrine glands synthesize and secrete hormones which control the activities of animals.	

TOPICS	UNDERSTANDINGS	TEACHER NOTES
	Hormones are chemicals secreted in one area of the body which affect responses in other areas.	
	The circulatory system aids in the distribution of these hormones since the endocrine glands are ductless.	
b. Role of Animal Hormones	Current research indicates that hormones exist in a wide variety of organisms and that the hormones themselves have wide distribution among animals.	
	Hormones interact and exert control on metabolic activities such as metamorphosis and reproduction.	
*VI. Locomotion	Locomotion is the ability to move from place to place.	
A. Advantages	Locomotion increases the probability of survival among animals and many protista. Some of the advantages of locomotion are increased opportunities to obtain food, seek shelter, avoid predators, move away from toxic wastes, and mate.	
B. Adaptations		
1. Protista		
a. Algae	Some algae move by means of flagella.	
b. Protozoans	The locomotive structures utilized by paramecia are cilia. Locomotion in ameba is by pseudopods.	
2. Animals		
a. Hydra	The hydra is essentially a sessile organism. The presence of contractile fibers permits some motion, including a type of somersaulting.	

TOPICS	UNDERSTANDINGS	TEACHER NOTES
b. Earthworm	Locomotion is accomplished through the interactions of muscles and setae. The setae permit temporary anchorage in the soil and the muscles produce extensions and contractions of the animal's body.	
c. Grasshopper	The grasshopper has an exoskeleton made of chitin. Locomotion is accomplished by interactions of muscles with jointed, chitinous appendages.	
d. Human	Humans have an endoskeleton. Locomotion is accomplished by the interaction of muscles and jointed appendages.	

Unit III - Human Physiology

UNIT III — HUMAN PHYSIOLOGY

OBJECTIVES

The student should be able to:

- Recognize that humans are not unique in their performance of the functions necessary to maintain life.
- Apply scientific information to food choice decisions.
- Identify the major structures and functions of the human body and their role in the maintenance of homeostasis.
- Describe the interrelationships among the systems of the human body.
- Describe the structure and function of the major organs of the human body.

TOPICS	UNDERSTANDINGS	TEACHER NOTES
*I. Nutrition	Nutrition includes those activities by which organisms obtain and process nutrients needed for energy, growth, repair, and regulation. Humans are heterotrophic and therefore, must ingest food. Food includes nutrients and roughage. Nutrients include usable carbohydrates, protein, lipids, vitamins, minerals, and water. Vitamins, minerals, and water are small molecules and can be absorbed without digestion. Carbohydrates, lipids, and proteins require digestion. Nutritional requirements vary with an individual's age, sex, and activities.	Note pages 20-27 in Unit II for introductory materials.
A. Functional Organization	The human digestive system consists of a continuous one-way gastrointestinal tract and the accessory organs which function in conjunction with the tract. Food is moved through the GI tract by slow, rhythmic muscular contractions called peristalsis.	
1. Oral Cavity	Ingestion of food occurs through the mouth. The oral cavity contains the teeth, tongue, and the openings from the salivary glands.	

The teeth function in the mechanical breakdown of food which serves to increase the surface area of the food for enzyme action.

The chemical digestion of carbohydrates begins here. The salivary glands secrete saliva which contains the enzyme amylase which digests starch.

> HP
>
> Carbohydrates, which should constitute 50 percent of the diet, are a source of energy for the body.
>
> In addition to serving as energy sources, complex carbohydrates provide nondigestible materials which increase the amount of roughage. Complex carbohydrates are found in fresh fruits and vegetables as well as whole grains.

2. Esophagus

As a result of swallowing, food moves into the esophagus. Peristaltic action of the esophagus moves the food to the stomach.

3. Stomach

The stomach is a muscular organ. Its lining contains gastric glands which secrete enzymes and hydrochloric acid. Hydrochloric acid provides an optimum pH for the hydrolytic activity of gastric protease. Under the influence of this enzyme, protein digestion begins.

4. Small Intestine

Partially digested food enters the small intestine. The small intestine is a long, convoluted tube in which the major portion of food is digested.

Accessory structures, the gall bladder and pancreas, empty their secretions into the small intestine.

TOPICS	UNDERSTANDINGS	TEACHER NOTES
	The secretion from the gall bladder is bile. Bile is produced in the liver and stored in the gall bladder. Bile emulsifies fats in the small intestine. Emulsification serves to increase the surface area of fats for subsequent chemical action.	
a. Chemical Digestion	The pancreas secretes several enzymes including intestinal protease, lipase, and amylase.	
	Intestinal glands that line the intestinal wall secrete protease, lipase, and disaccharidases, such as maltase.	
	Chemical digestion of proteins, lipids, and carbohydrates is completed here.	Note page 25 in Unit II for digestive products.
b. Absorption	The lining of the small intestine contains numerous villi which increase the surface area to facilitate absorption. Capillaries and small lymphatic vessels, lacteals, extend into the villi.	
	Fatty acids and glycerol are absorbed through the villi into the lacteals and are transported in the lymph.	
	Monosaccharides and amino acids are absorbed through the villi and enter the capillaries to be transported to the liver where they are temporarily stored. From there they are available for distribution by the blood.	
	HP	
	Glucose is stored as the polysaccharide glycogen. Breakdown of glycogen releases glucose for transport.	The role of hormones in the storage and release of glucose will be discussed on page 68.

TOPICS	UNDERSTANDINGS	TEACHER NOTES
	HP continued	
	Amino acids are temporarily stored and distributed to the cells as needed for protein synthesis.	
	Twenty amino acids are necessary for body cells to synthesize the required proteins needed to maintain and repair body tissues.	
	Although humans can convert one amino acid into another, eight cannot be synthesized and must be consumed as part of the diet. These are called essential amino acids.	
	In order to synthesize new proteins, all the necessary amino acids must be present at the same time. If there is an insufficient supply of any one amino acid, protein synthesis will be limited, and the amino acids will be deaminated and used for energy production.	
	Complete protein foods provide all the essential amino acids.	Reference might be made to the role of complementary foods in vegetarian diets.
	Incomplete proteins lack one or more of the essential amino acids. A balanced diet may be attained by making incomplete protein foods complement each other.	Incomplete protein foods (wheat and beans) complement each other more effectively if they are eaten at the same time.
5. Large Intestine	Undigested food and water enter the large intestine where water is absorbed. Strong peristaltic action forces feces out through the anus.	

B. Mechanism for Chemical Digestion

Hydrolysis is the splitting of large, insoluble molecules into small, soluble molecules with the addition of water. In organisms, this process is regulated by hydrolytic enzymes and is illustrated by the following:

$$\text{maltose + water} \xrightarrow{\text{maltase}} \text{glucose + glucose}$$

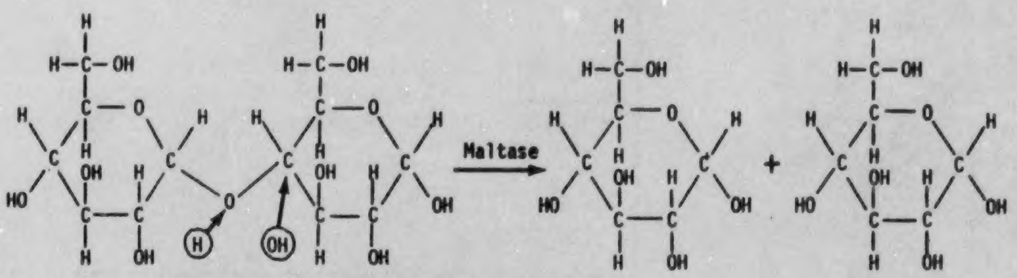
$$\text{proteins + water} \xrightarrow{\text{protease}} \text{amino acids}$$

$$\text{lipids and water} \xrightarrow{\text{lipase}} \text{3 fatty acids and 1 glycerol}$$

In a similar fashion, polysaccharides such as starch, are completely hydrolyzed to simple sugars.

BC

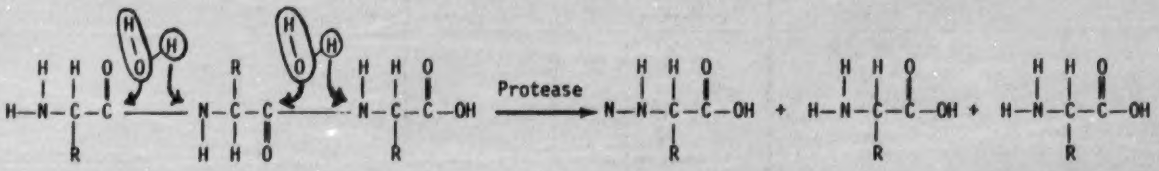
The process of hydrolysis is illustrated by the following equations representing the breakdown of the disaccharide, maltose, into two glucose molecules.



$$\text{Maltose + water} \xrightarrow{\text{Maltase}} \text{Glucose + Glucose}$$

BC continued

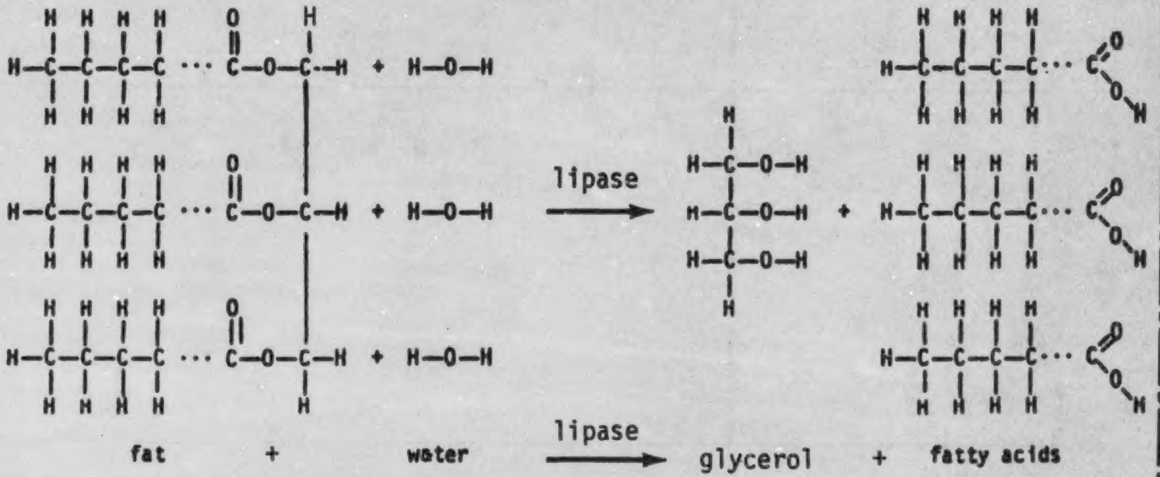
During hydrolysis, in the presence of water and proteases, the peptide bonds are broken resulting in the production of amino acids.



$\text{Polypeptide} + \text{water} \xrightarrow{\text{protease}} \text{amino acids}$

BC

In the presence of water molecules and lipase, lipids are hydrolyzed to one glycerol and three fatty acid molecules.



HP

Fats contain a high quantity of potential energy and are necessary for the synthesis of cell membranes. However, increased fat consumption represents a potentially dangerous change in an individual's dietary pattern. It is important to be aware of not only how much but also what kind of fat is eaten. Fats are described as saturated or unsaturated.

Reference might be made to the structural formulas of saturated and unsaturated fats.

136

137

TOPICS	UNDERSTANDINGS	TEACHER NOTES
HP continued	Saturated fats are solid at room temperature. There is evidence that increased intake is one of many factors that predisposes humans to cardiovascular disease. Polyunsaturated fats (oils) are liquid at room temperature and do not appear to be linked to cardiovascular diseases.	Cardiovascular diseases are discussed on pages 58 - 59.
C. Some Malfunctions of the Digestive System		
1. Ulcers	An erosion of the surface of the alimentary canal generally associated with some kind of irritant	
2. Constipation	A condition in which the large intestine is emptied with difficulty. Too much water is absorbed and the solid waste hardens.	
3. Diarrhea	A gastrointestinal disturbance characterized by decreased water absorption and increased peristaltic activity of the large intestine. This results in increased, multiple, watery feces. This condition may result in severe dehydration.	
4. Appendicitis	An inflammation of the appendix	
5. Gallstones	An accumulation of hardened cholesterol deposits in the gall bladder	

TOPICS	UNDERSTANDINGS	TEACHER NOTES
*II. Transport	The process of transport involves the absorption and circulation of materials throughout an organism.	Note pages 27-29 in Unit II for introductory material.
*A. Functional Organization	A function of the human circulatory system is the transport of dissolved and suspended materials throughout the body.	
*1. Transport Media		
a. Blood	Blood is a fluid tissue composed of plasma in which red blood cells, white blood cells, and platelets are suspended. Blood, serving as a transport medium, helps to maintain homeostasis for all cells of the body.	
1) Plasma	The plasma, which is made up mostly of water, contains dissolved inorganic ions, wastes, hormones, nutrients, and a variety of proteins including antibodies, clotting factors, and enzymes.	
2) Red Blood Cells	Red blood cells, which lack nuclei when mature, contain hemoglobin which combines with and distributes oxygen.	
3) Platelets	Platelets are smaller than either red or white blood cells and play a key role in blood clot formation.	

HP Clotting

Blood clotting involves a series of enzyme-controlled reactions resulting in the formation of protein fibers that trap blood cells and form a clot.

Although all reactants are present in the blood, the rupturing of the platelets and the release of an enzyme appear to initiate the process.

TOPICS	UNDERSTANDINGS	TEACHER NOTES
4) White Blood Cells	Several types of white blood cells exist.	
a) Phagocytic White Blood Cells	Phagocytic white blood cells engulf and destroy bacteria at the site of infection by the process of phagocytosis. This is a normal defense against infection.	
b) Lymphocytes	Lymphocytes are another type of white blood cell that is associated with the immune response. These white blood cells produce specific antibodies which act against foreign molecules known as antigens.	
HP (1) Immunity	Immunity involves the accumulation of specific antibodies in the plasma of the blood enabling the individual to resist specific diseases. Immunity can be acquired in the following ways:	
(a) Active Immunity	The antigen - antibody reaction occurs within the body in response to either contact with the disease-causing organisms or their products, or by receiving a vaccination.	Discussions pertaining to immunization and its role in limiting the incidence of disease could be helpful.
(b) Passive Immunity	A temporary form of immunity can be produced by the introduction of antibodies into the body.	
(2) Allergies	Many people are allergic to various substances -- dust, pollen, insect bites, foods, drugs, and others. The body responds to these substances as if they were antigens and produces antibodies.	

HP continued

These antibodies may cause inflammations and/or result in the release of a chemical substance called histamine. The histamine causes the allergic response.

(3) Applications

Knowledge of immunity has resulted in the ability to type blood and transplant organs.

(a) Blood Typing

Blood typing in the ABO blood group is based on the presence or absence of antigens on the surface of red blood cells. Two types of antigens are known: "A" and "B."

In addition, plasma may contain the antibodies, anti-A and/or anti-B.

Antigens in red cells	Antibodies in plasma	Blood Type
A	Anti-B	A
B	Anti-A	B
A & B	Neither Anti-A nor Anti-B	AB
Neither A nor B	Anti-A & Anti B	O

(b) Organ Transplants

Rejection of organ transplants occurs when the recipient's body produces antibodies in response to the antigens present in the donor's organ.

b. ICF and Lymph

Intercellular fluid (ICF) derived from blood plasma surrounds all living cells of the body. When ICF passes into the lymph vessels it is called lymph.

144

145

TOPICS	UNDERSTANDINGS	TEACHER NOTES
2. Transport Vessels		
a. Arteries	Arteries are relatively thick-walled, muscular, blood vessels which transport blood from the heart to all parts of the body. Their contraction (pulse) aids in the flow of blood.	
b. Capillaries	Capillaries are tiny blood vessels with walls only one cell thick. They readily exchange materials between the blood and the intercellular fluid.	
c. Veins	Veins are relatively thin-walled blood vessels possessing valves which prevent the backflow of blood. The veins return blood to the heart.	
d. Lymph Vessels	Lymph vessels include extremely small tubes with walls only one cell thick. These vessels branch through all the body tissues. Major lymph vessels have lymph nodes which contain phagocytic cells which filter bacteria and dead cells from the lymph. Valves, present in some lymph vessels, aid in the movement of the lymph.	
*3. Transport Mechanisms		
a. Structure and Function	The muscular heart is a four-chambered pump composed of two atria and two ventricles. The ventricles have thicker walls than the atria. The heart pumps blood through the arteries creating a blood pressure.	
HP		
1) Circulation Through the Heart	The right atrium receives deoxygenated blood from the body through the vena cavae. The left atrium receives oxygenated blood from the lungs through the pulmonary vein. Blood passes through valves from the atria to the ventricles. Valves prevent the backflow of blood into the atria. The right ventricle pumps deoxygenated blood to the lungs through the pulmonary artery; the	

TOPICS	UNDERSTANDINGS	TEACHER NOTES
HP continued	left ventricle pumps oxygenated blood to the rest of the body through the aorta. Valves between these arteries and the ventricles prevent the backflow of blood into the ventricles. Blood pressure refers to the pressure exerted on the walls of the arteries during the pumping action of the heart. During the contraction of the ventricles (systole), great pressure is exerted on the arterial walls; during the relaxation of the ventricles (diastole), less pressure is normally exerted on the arterial walls.	
2) Pulmonary and Systematic Circulation	Circulation to and from the lungs is pulmonary circulation. Circulation to and from the rest of the body is systemic circulation.	
3) Coronary Circulation	The muscle tissue of the heart is supplied with blood through a system of coronary blood vessels.	
4) Lymphatic Circulation	Tissue fluid may be drained through lymph vessels. These lymph vessels join larger vessels which ultimately form two main trunks that empty lymph into certain veins of the circulatory system.	
B. Some Malfunctions of the Transport System		
1. Cardiovascular Diseases	Cardiovascular diseases are malfunctions involving the heart and blood vessels.	
a. High Blood Pressure	High blood pressure is the most common form of cardiovascular disease characterized by increased arterial pressure. This can be caused by a number of variables including stress, dietary factors, heredity, cigarette smoking, and aging. High blood pressure can lead to damage to the lining of arteries and a weakening of the heart muscle.	

TOPICS	UNDERSTANDINGS	TEACHER NOTES
HP continued		
b. "Heart Attack"	Heart attacks, as they are called, include:	
1) Coronary Thrombosis	Coronary Thrombosis is a blockage in the coronary artery or its branches resulting in O_2 deprivation in the heart muscle. The deprived muscle usually becomes damaged.	
2) Angina Pectoris	Angina Pectoris is a narrowing of the coronary arteries causing an inadequate supply of oxygen to the heart muscle. Often, an intense pain radiating from chest to shoulder and arms is felt.	
2. Blood Conditions	Blood conditions are abnormalities in the circulatory fluid.	Sickle-cell anemia is discussed on page 101.
a. Anemia	Anemia is the impaired ability of the blood to transport sufficient amounts of oxygen. This can be due to reduced amounts of hemoglobin and/or red blood cells.	
b. Leukemia	Leukemia is a disease of the bone marrow characterized by uncontrolled production of non-functional white blood cells.	
III. Respiration	Respiration involves the processes of cellular respiration and gas exchange.	Note page 32 of Unit II for introductory material on respiration.
A. Cellular	In humans the process of cellular respiration is essentially the same as that of other aerobic organisms. Under conditions of oxygen deprivation, muscle cells respire anaerobically, and lactic acid is produced.	
B. Gas Exchange	The function of the human respiratory system is to transport gases between the external environment and the internal gas exchange surfaces.	

TOPICS	UNDERSTANDINGS	TEACHER NOTES
1. Functional Organization of the Respiratory System	The respiratory system is composed of a network of passageways which permit air to flow from the external environment to the lungs.	
a. Nasal Cavity	The nasal cavity is exposed to the air through nostrils. This cavity is lined with a ciliated mucous membrane which filters, warms, and moistens the air.	
b. Pharynx	The pharynx is the area in which the oral cavity and nasal cavity meet. Food is prevented from entering the trachea by the epiglottis.	
c. Trachea	The trachea is kept open by rings of cartilage. The ciliated mucous membrane which lines the trachea traps microscopic particles and sweeps them toward the pharynx. Deposits from cigarette smoke and other atmospheric pollutants may interfere with the action of cilia.	
d. Bronchi	The two major subdivisions of the trachea are the bronchi. The bronchi are lined with mucous membrane and ringed with cartilage. Each bronchus extends into a lung where it subdivides many times forming progressively smaller bronchioles.	
e. Bronchioles	Bronchioles are lined with mucous membrane but lack cartilage rings. Tiny bronchioles terminate with the alveoli.	
f. Alveoli	Alveoli are the functional units for gas exchange. They are thin, moist, and surrounded by capillaries.	
g. Lung	Each bronchus with its bronchioles and alveoli is called a lung.	

TOPICS	UNDERSTANDINGS	TEACHER NOTES
2. Mechanisms for Gas Exchange		
a. Breathing	The lungs are highly elastic and respond passively to the actions of the diaphragm and rib cage. Movements of the diaphragm and rib cage cause pressure changes in the chest cavity which move air into or out of the lungs. This process is known as breathing. The breathing rate is regulated by the concentration of CO_2 in the blood and its effect on the medulla of the brain. This is an example of a feedback mechanism which aids in the maintenance of homeostasis.	
b. Gas Exchange	The capillaries which surround the alveoli are involved in gas exchange between the blood and the alveoli. In the blood, oxygen is carried by the red blood cell as oxyhemoglobin. Oxygen, which is loosely bound to the hemoglobin, diffuses into the cells where it is used during aerobic cellular respiration. The end products of aerobic cellular respiration, CO_2 and H_2O, diffuse into the blood. Carbon dioxide is carried primarily in the plasma in the form of the bicarbonate ion. CO_2 and H_2O are released from the lungs.	
HP		
C. Some Malfunctions of the Respiratory System		
1. Bronchitis	Bronchitis is the inflammation of the membrane of the bronchial tubes.	

155

154

TOPICS	UNDERSTANDINGS	TEACHER NOTES
HP continued		
2. Asthma	Asthma is an allergic response characterized by constriction of the bronchial tubes.	
3. Emphysema	Emphysema is a change in the structure of the lung characterized by enlargement and degeneration of the alveoli resulting in decreased lung capacity.	
*IV. Excretion		
	Many organs are involved in the removal of metabolic wastes in humans.	Note page 37 of Unit II.
A. Functional Organization		
1. Lungs	Carbon dioxide and water, waste products of respiration, diffuse from the blood into the alveoli. These gases are removed from the body during exhalation.	
2. Liver	The liver is a large, multi-purpose organ whose excretory functions include the breakdown of red blood cells and the production of urea following amino acid deamination.	
3. Sweat Glands of the Skin	Water, salts, and some urea diffuse from the blood into the sweat glands and are subsequently excreted as perspiration. Perspiration is only incidentally excretory, its primary function being temperature regulation. Evaporation of the sweat (98% water and 2% salts and urea) occurs when heat is absorbed from skin cells. This absorption of heat lowers body temperature. Temperature regulation is an example of homeostasis.	

TOPICS	UNDERSTANDINGS	TEACHER NOTES
4. Urinary System		
a. Kidneys	The kidneys perform two major functions: - They excrete most of the urea. - They control the concentration of most of the constituents of the body fluids.	
	Arteries bring blood to the kidneys where microscopic nephrons are involved in filtration and reabsorption. Water, salts, urea, amino acids, and glucose are filtered from the glomerulus into the cuplike Bowman's capsule. As these materials move through the tubule of the nephron, water, minerals, and digestive end products are reabsorbed by active transport into capillaries associated with the tubule. Veins carry blood away from the kidneys.	Blood pressure plays a vital role in filtration.
	After reabsorption, the fluid that remains in the tubule is urine.	
b. Ureter	Urine flows from the kidneys through the ureters to the urinary bladder.	
c. Urinary Bladder	The urinary bladder stores the urine.	
d. Urethra	Periodically, urine is excreted from the bladder through the urethra.	
HP		
B. Malfunctions		
1. Kidney Diseases	Diseases associated with the malfunctioning of the kidney or the nephron	Reference might be made to the relationship of extremely high protein diets to kidney malfunctions.
2. Gout	A disease associated with uric acid production and its deposition in the joints resulting in arthritic-like attacks	

TOPICS	UNDERSTANDINGS	TEACHER NOTES
*V. Regulation	Regulation is achieved by the integration of the nervous system and the endocrine system. The nervous and endocrine systems of humans show certain similarities and certain differences. Similarities include: - Both secrete chemicals. - Both play a major role in homeostasis. Differences include: - Nerve responses are more rapid than endocrine responses. - Nerve responses are of shorter duration than endocrine responses.	Note pages 39-43 in Unit II.
A. Nervous System		
1. Functional Organization		
a. Neurons	The neuron is the basic cellular unit of the nervous system. The nervous system is composed of three structurally different types of neurons: sensory neurons, interneurons, and motor neurons.	
1) Sensory Neurons	Sensory neurons transmit impulses from receptors to the brain and spinal cord. Sense organs are structures where sensory neurons are concentrated. These include the eyes, ears, tongue, nose, and skin.	
2) Motor Neurons	Motor neurons transmit impulses from the central nervous system to effectors.	
3) Interneurons	Interneurons relay nerve impulses between sensory and motor neurons.	Interneuron is the new term for associative neuron.

TOPICS	UNDERSTANDINGS	TEACHER NOTES
b. Nerves	Nerves are bundles of neurons or parts of neurons. They can be sensory nerves, motor nerves, or mixed nerves. Nerves are specialized for the transmission of impulses over long distances.	
c. Central Nervous System		
1) Brain	The brain is a large mass of neurons located in the cranial cavity. The cerebrum, the cerebellum, and the medulla are the three major divisions of the brain, each having specialized functions.	
a) Cerebrum	The cerebrum is the center for voluntary activity. In specific areas, sensory impulses are interpreted, motor activities may be initiated, and memory, thinking, and reasoning occur. Habits, which are acquired by repetition, are examples of conditioned behavior. The repetition establishes pathways for nerve impulse transmission which permit rapid automatic responses to various stimuli.	
b) Cerebellum	The cerebellum coordinates motor activities and aids in maintaining balance.	
c) Medulla	The medulla controls involuntary activities such as breathing, heartbeat, blood pressure, and peristalsis.	
2) Spinal Cord	The spinal cord lies within, and is protected by, the vertebrae of the spinal column. The spinal cord is continuous with the brain. The spinal cord coordinates activities between the brain and other body structures. It is a center for reflex actions.	

TOPICS	UNDERSTANDINGS	TEACHER NOTES
	Reflex actions are inborn, involuntary patterns of behavior.	
	Reflex behavior involves a pathway (reflex arc) over which impulses travel. In a spinal reflex there is a pathway from receptors to a sensory neuron to interneurons in the spinal cord to a motor neuron to an effector.	
d. Peripheral Nervous System	The peripheral nervous system is located outside the central nervous system and consists of nerves extending throughout the body.	
HP		
	The peripheral nervous system is separated into the somatic and autonomic nervous systems.	
1) Somatic Nervous System	It consists of nerves that control the voluntary muscles of the skeleton.	
2) Autonomic Nervous System	The autonomic nervous system consists of the nerves that control cardiac muscle, glands, and smooth muscle. It is generally considered to be an involuntary system.	The distinction between "voluntary" and "involuntary" is not clear-cut.
2. Some Malfunctions of the Nervous System		
a. Cerebral Palsy	A group of congenital diseases characterized by a disturbance of the motor functions.	
b. Meningitis	Inflammation of the membranes surrounding the brain and spinal cord.	

TOPICS	UNDERSTANDINGS	TEACHER NOTES
HP continued		
c. Stroke	A disease resulting from a cerebral hemorrhage or a blood clot in the cerebral vessel which may result in brain damage.	
d. Polio	A viral disease of the central nervous system which may result in paralysis and is preventable through immunization.	
*B. Endocrine System	The endocrine glands, located in various parts of the body, and their hormones, make up the endocrine system. Hormones are transported by the circulatory system and affect various tissues or organs.	Note pages 42-43 in Unit II.
HP		
1. Functional Organization		
a. Hypothalamus	The hypothalamus is a small region of the brain. Although part of the central nervous system, it has an endocrine function. It produces hormones which influence the pituitary gland.	
b. Pituitary Gland	The pituitary gland, located at the base of the brain, secretes numerous hormones. One of these hormones, a growth-stimulating hormone, has widespread effect on the body. The growth-stimulating hormone stimulates the elongation of long bones. Other pituitary hormones control specific endocrine glands. Examples of these include: - Thyroid Stimulating Hormone (TSH) -- stimulates the thyroid gland to produce its hormone, thyroxin. - Follicle Stimulating Hormone (FSH) -- stimulates activity in the ovaries and testes.	

TOPICS	UNDERSTANDINGS	TEACHER NOTES
HP continued		
c. Thyroid Gland	The thyroid gland, which is located in the neck. produces thyroxin, which contains iodine. Thyroxin regulates the rate of metabolism in the body and is essential for normal physical and mental development.	
d. Parathyroid Glands	The parathyroid glands, patches of tissue embedded in the thyroid gland, produce and secrete the hormone parathormone. Parathormone controls the metabolism of calcium which is necessary for nerve function, blood clotting, and proper growth of teeth and bones.	
e. Adrenal Glands	The adrenal glands are two small glands located on top of the kidneys. Each gland consists of two distinct regions. The outer portion is the adrenal cortex,and the inner mass is the adrenal medulla.	
	The adrenal cortex secretes two types of steroid hormones. One type promotes the conversion of body fat and protein into glucose. The other type promotes the reabsorption into the blood stream of sodium and chloride ions by the kidney tubules. This affects the water balance and helps maintain blood pressure.	
	The adrenal medulla secretes adrenalin in times of emergency. Adrenalin increases the blood sugar level and accelerates the heart and breathing rates.	
f. Islets of Langerhans	The islets of Langerhans are small groups of cells located in the pancreas. They secrete the hormones insulin and glucagon.	
	Insulin facilitates the entrance of glucose into the cells. It lowers blood sugar levels by promoting the movement of sugar from the blood into the liver and muscles where it is stored as glycogen. Glucagon stimulates the release of sugar from the liver into the blood.	

TOPICS	UNDERSTANDINGS	TEACHER NOTES
HP continued		
g. Gonads	Testes, the male sex glands, secrete testosterone which influences the development of the male secondary sex characteristics. In the female, ovaries are responsible for the secretion of several hormones. One of these ovarian hormones is estrogen which influences the development of the female secondary sex characteristics.	
2. Mechanisms	A type of self-regulation, known as negative feedback, is associated with endocrine regulation. The negative feedback mechanism operates on the principle that the level of one hormone in the blood stimulates or inhibits the production of another hormone. The relationship between TSH and thyroxin is an illustration of the homeostatic feedback mechanism in the body.	
3. Malfunctions		
a. Goiter	Enlargement of the thyroid gland usually resulting from the gland's inability to manufacture thyroxin. This is often associated with an iodine deficiency in the diet.	
b. Diabetes	A disorder characterized by an insulin deficiency which results in an elevated blood sugar level	
VI. Locomotion	Human locomotion involves the interaction of bones, cartilage, muscles, tendons, and ligaments.	
A. Functional Organization		
1. Bones	The human endoskeleton consists of bones of various shapes and sizes. The functions of the bones include: support and protection of body structures, anchorage sites for muscle action, leverage for body movement, and production of blood cells in the marrow.	

TOPICS	UNDERSTANDINGS	TEACHER NOTES
2. Cartilage	Although the human skeleton consists primarily of bone, another type of connective tissue, cartilage, is also present. Cartilage is flexible, fibrous, and elastic. The functions of cartilage include: pliable support, flexibility of joints, and cushioning effects in joints. Cartilage is found in both the embryo and the adult. Embryo -- Cartilage makes up most of the embryo's skeleton. By adulthood most of this cartilage is replaced by bone. Adult -- Cartilage is found at the end of ribs between vertebrae, at the ends of bones, and in the nose, ears, and trachea.	
3. Muscles	There are three major types of muscles in the human body: visceral muscles which are involuntary in action and smooth in appearance; cardiac muscles which are involuntary in action and striated in appearance; and skeletal muscles which are voluntary in action and striated in appearance. Skeletal muscles are controlled by the nervous system. They serve to move the bones in a coordinated manner. Muscles usually operate in pairs which include: extensors which extend limbs and flexors which return the limbs. Vigorous activity of skeletal muscles may lead to an oxygen deficiency which can result in anaerobic respiration and a buildup of lactic acid. Lactic acid production is associated with fatigue.	
4. Tendons	Tendons are composed of connective tissue. They are tough, inelastic, fibrous cords which attach muscles to bones.	

TOPICS	UNDERSTANDINGS	TEACHER NOTES
5. Ligaments	Ligaments are composed of tough elastic connective tissue. Ligaments connect the ends of bones at moveable joints such as the elbow, fingers, knee, and vertebral column.	
HP		
B. Some Malfunctions Associated with Locomotion		
1. Arthritis	An inflammation of the joints	
2. Tendonitis	An inflammation of the tendon usually at the bone juncture. This condition is common to athletes.	

Unit IV - Reproduction and Development

UNIT IV — REPRODUCTION AND DEVELOPMENT

OBJECTIVES

The student should be able to:

- Describe the processes of mitosis, meiosis, and fertilization.
- Recognize the role of mitosis, meiosis and fertilization in reproductive cycles.
- Compare the processes of asexual and sexual reproduction in terms of methods and results.
- Compare the adaptations for sexual reproduction and development in both plants and animals.
- Explain the relationships among numbers of eggs, methods of fertilization, and sites of embryonic development, as they relate to species survival.
- Describe the development of plant and animal embryos.
- Describe hormonal interactions in the human male and female.

TOPICS	UNDERSTANDINGS	TEACHER NOTES
I. Asexual Reproduction	Asexual reproduction is the production of new organisms without the fusion of nuclei. The new organisms develop from a cell or cells of the parent.	
*A. Mitotic Cell Division	All cells arise from other cells by cell division. This process involves both nuclear duplication and cytoplasmic division. - Mitosis -- an orderly series of complex changes in the nucleus, normally involving an exact duplication of the complete set of chromosomes and the separation of these chromosomes into two identical sets - Cytoplasmic Division -- the division of cytoplasm which occurs either during or after mitosis resulting in the formation of two daughter cells each containing an identical set of chromosomes	

TOPICS	UNDERSTANDINGS	TEACHER NOTES
1. Processes		
a. Mitosis	The process of mitosis involves: - Replication of each single-stranded chromosome during the nondividing period, resulting in double-stranded chromosomes. Individual strands of a double-stranded chromosome are known as chromatids and are joined by a centromere. - Disintegration of the nuclear membrane during the early stages of division - Synthesis of a spindle apparatus - Attachment of double-stranded chromosomes to the spindle apparatus at the centromere region of the chromosomes - Replication of each centromere which results in the formation of two single-stranded chromosomes, which are moved along the spindle apparatus to opposite ends of the cell - Nuclear membrane formation around each set of chromosomes, forming two nuclei The major result of mitosis is the formation of two daughter nuclei which are identical to each other and to the original nucleus, in the number and types of chromosomes.	
b. Cytoplasmic Division	Division of the cytoplasm usually, but not always, accompanies mitosis. The methods of cytoplasmic division differ in plant and animal cells.	
2. Comparison Between Plant and Animal Mitotic Cell Division	Mitosis is similar in plant and animal cells. However, in animal cells, centrioles aid in the formation and orientation of the spindle apparatus. Cytoplasmic division is accomplished in animal cells by a "pinching in" of the cell membrane, thus separating the two nuclei; while in plant cells, a cell plate is synthesized.	

TOPICS	UNDERSTANDINGS	TEACHER NOTES
3. Uncontrolled Cell Division	Cancer is a group of diseases often characterized by uncontrolled cell division of certain abnormal cells.	
B. Types of Asexual Reproduction		
1. Binary Fission	Binary fission involves the equal division of the nuclear materials and cytoplasm of an organism resulting in two new organisms.	
2. Budding	In unicellular organisms such as yeast, budding is similar to fission except that the cytoplasmic division is unequal. The new cells may detach from each other or may remain together and form a colony. In multicellular organisms such as hydra, budding refers to the production of a multicellular outgrowth from the parent organism. The bud and the parent may detach from each other or may remain together and form a colony.	
3. Sporulation	In many organisms, spores, which are single,specialized cells, are released from the parent and can develop into new individuals. (Example: bread mold.)	
4. Regeneration	Regeneration is the development of an entire new organism from a part of the original organism. An example is the starfish which may develop from a single ray and part of the central disc. Regeneration also refers to the replacement of lost structures. A lobster may regenerate a lost claw. Generally, invertebrate animals possess more undifferentiated cells than do vertebrate animals. As a result, invertebrates exhibit a higher degree of regenerative ability than most vertebrates.	

TOPICS | UNDERSTANDINGS | TEACHER NOTES

5. Vegetative Propagation

Some multicellular plants reproduce asexually by vegetative propagation. In this process new plants develop from roots, stems, or leaves of the parent plant. Some examples of vegetative propagation include:

Examples:	Organisms:
cuttings	coleus, geranium
bulbs	onion
tubers	potato
runners	strawberry
grafting	seedless orange

The use of local examples is encouraged.

II. Sexual Reproduction

Sexual reproduction involves the production of specialized sex cells (gametes) and the fusion of their nuclei (fertilization) producing a fertilized egg cell (zygote).

A. Reproduction and Development in Animals

1. Gametogenesis

Each body cell of an organism contains the diploid (2n) number of chromosomes characteristic of that species. These chromosomes are present in homologous pairs. Homologous chromosomes contain genes for the same traits.

Gametogenesis is the process in which gametes are produced. It involves meiotic cell division and cell maturation. This process occurs in specialized organs called gonads. Some organisms have only male or female gonads while others have both and are called hermaphrodites.

a. Meiosis

Meiosis is a process which involves reduction division. During this process, the chromosome number is reduced by one-half and monoploid nuclei which contain one chromosome of each homologous pair are formed.

TOPICS	UNDERSTANDINGS	TEACHER NOTES
1) Process		
a) First Meiotic Division	The process of meiosis involves two divisions.	
	The first meiotic division is the reduction division and involves: - Replication of each single-stranded chromosome during the nondividing period, resulting in double-stranded chromosomes - Synapsis -- the intimate pairing of homologous chromosomes, resulting in the formation of tetrads - Alignment of homologous pairs in the middle of the spindle apparatus - Disjunction of the homologous pairs and their subsequent movement along the spindle apparatus toward opposite ends of the cell - Cytoplasmic division.	Teachers may wish to discuss crossing over at this time. Note page 96 in Unit V.
b) Second Meiotic Division	The second meiotic division involves: - Alignment of double-stranded chromosomes in the middle of the spindle apparatus - Replication of centromeres - Migration of single-stranded chromosomes along the spindle apparatus toward opposite ends of the cell - Cytoplasmic division.	
	As a result of meiosis, diploid (2n) primary sex cells divide and form monoploid (n) cells which mature into specialized reproductive cells.	
	The distribution of the homologous chromosomes between the resultant nuclei is random, resulting in variation.	

TOPICS	UNDERSTANDINGS	TEACHER NOTES
2) Comparison With Mitotic Cell Division	Mitosis is associated with growth and asexual reproduction; meiosis, with sexual reproduction. As a result of mitotic cell division, the daughter cells are identical to the original cell. As a result of meiotic cell division, daughter cells have one-half the number of chromosomes of the original cell.	
b. Spermatogenesis	The male gonads, testes, produce male gametes, sperm. The primary sex cell undergoes meiosis and produces four monoploid cells. Each of these cells usually matures into a motile sperm cell.	
c. Oogenesis	The female gonad is the ovary,and the gamete is the ovum (egg). The ovum is larger than the sperm and contains stored nutrients in the form of yolk. Only one monoploid egg cell is usually formed from each primary sex cell that undergoes meiosis and maturation. The other cells produced are polar bodies. These result from unequal cytoplasmic divisions and degenerate.	
2. Fertilization	Fertilization is the union of a monoploid sperm nucleus (n) with a monoploid egg nucleus (n). In the resulting diploid zygote, the species number of homologous chromosomes (2n) is restored.	
a. External Fertilization	Reproduction in many aquatic vertebrate animals such as fish and amphibians is characterized by external fertilization. The gametes fuse outside the body of the female. Usually,large numbers of eggs are required to insure species survival.	
b. Internal Fertilization	Reproduction in most terrestrial vertebrate animals is characterized by internal fertilization. The gametes fuse in the moist reproductive tract of the female.	

TOPICS	UNDERSTANDINGS	TEACHER NOTES
3. Embryonic Development		
a. Process	The zygote, or fertilized egg, undergoes a series of mitotic cell divisions called cleavage. Once cleavage begins, the zygote becomes a developing embryo.	
RD		
1) Cleavage	Cleavage is a series of mitotic cell divisions that leads to the formation of the blastula, a single layer of cells which is a hollow ball-type structure. During cleavage, there is no increase in individual cell size.	
2) Gastrulation	In certain animals, one side of the blastula becomes indented (gastrulation) forming the gastrula, which has an inner layer, the endoderm, and an outer layer, the ectoderm. A third layer, the mesoderm, forms between the ectoderm and the endoderm.	
3) Differentiation	These three embryonic layers differentiate and give rise to the various tissues, organs, and systems of the multicellular animal. - The nervous system and the skin originate from the ectoderm layer. - The muscles, circulatory system, skeleton, excretory system, and gonads originate from the mesoderm layer. - The lining of the digestive and respiratory tracts, and portions of the liver and pancreas, originate from the endoderm.	
4) Growth	Growth is an increase in cell number as well as in cell size. Early development consists chiefly of the differentiation and growth of cells and tissues.	

TOPICS | UNDERSTANDINGS | TEACHER NOTES

b. Site

1) External Development

External development occurs outside of the female's body.

RD

a) In Water

The eggs of many fish and amphibians are fertilized externally and develop externally in an aquatic environment.

The developing embryo's source of food is the yolk stored in the egg.

b) On Land

Eggs of birds, many reptiles, and a few mammals develop externally on a land environment after internal fertilization.

The developing embryo's source of food is the yolk.

Some adaptations for animals which develop externally on land are a shell which provides protection and membranes which help provide a favorable environment for embryonic development. These embryonic membranes include:

- The amnion which contains the amniotic fluid. This fluid provides a watery environment, protects the embryo from shock, and prevents adhesion of embryonic tissues to the shell.
- The yolk sac which surrounds the yolk. Blood vessels which penetrate the yolk sac transport food to the developing embryo.
- The allantois which functions as a respiratory membrane and a storage site for the nitrogenous waste, uric acid.
- The chorion which is an outer membrane surrounding the other embryonic membranes.

TOPICS	UNDERSTANDINGS	TEACHER NOTES
2) Internal Development	Internal development involves the growth of the embryo within the body of the parent.	
a) Placental Mammals	Mammals have internal fertilization. The embryo(s) develops internally within a structure called the uterus. The eggs of mammals have relatively little yolk and therefore are very small. Within the uterus, a specialized organ, the placenta, is formed from embryonic and maternal tissues. It is through this structure that the exchange of nutrients, wastes, and respiratory gases between the mother and the embryo occurs. There is no direct connection between maternal and embryonic bloodstreams. Transport is accomplished by diffusion and active transport. An umbilical cord, containing blood vessels, attaches the embryo to the placenta. Humans are placental mammals. In a few mammals, such as the marsupials, there is no placenta.	
b) Marsupials	In marsupials, internal fertilization and internal embryonic development occur without direct nourishment from the parent. The source of food is the yolk stored in the egg. The embryo is born at a relatively premature stage compared to placental mammals, and completes its development externally in a pouch which contains mammary glands.	

RD

4. Reproduction and Development in Humans

   a. Gametogenesis

      1) Male Reproductive System

The male reproductive system performs two major functions: the production of sperm cells and the deposition of these cells within the female reproductive tract.

Sperm production occurs in the testes. The testes are located in the scrotum where the temperature is 1-2 degrees Celsius cooler than normal body temperature. This provides an optimum temperature for sperm production and storage.

From the testes, sperm move through several tubes including the urethra. The urethra is a tube contained within the penis. The penis is a structural adaptation for internal fertilization.

Glands secrete a liquid into these tubes. The liquid serves as a transport medium for the sperm -- an adaptation for life on land. This liquid and the sperm cells constitute semen.

In addition to producing sperm, the testes also produce the male sex hormone, testosterone. This regulates the maturation of sperm and the development of secondary sex characteristics, such as beard development and voice pitch.

      2) Female Reproductive System

Ovaries are paired structures located within the lower portion of the body cavity. Ovaries produce eggs in tiny cavities called follicles. Following ovulation, the egg cell is transported through an oviduct (Fallopian tube) to the uterus. At the lower end of the uterus known as the cervix is a muscular tube, the vagina.

RD continued

At birth, all of the potential eggs that a female will ovulate are present in immature form. Usually only one egg is released at the time of each ovulation.

In addition to eggs, the ovaries also produce the female sex hormones estrogen and progesterone. These regulate the development of secondary sex characteristics such as the development of the mammary glands and the broadening of the pelvis. The hormones also have a coordinating role in the menstrual cycle.

a) Menstrual Cycle

The menstrual cycle begins at puberty and ceases at menopause. Menopause is the permanent cessation of the menstrual cycle. The duration of this cycle is approximately 28 days but may vary considerably and may be interrupted by pregnancy, illness, and other factors.

The menstrual cycle consists of four stages:

- Follicle stage -- this stage involves the maturation of an egg within the follicle and the secretion of the hormone estrogen. Estrogen initiates vascularization of the uterine lining.
- Ovulation -- the release of an egg from the follicle
- Corpus luteum stage -- the corpus luteum forms from the follicle following ovulation. It secretes progesterone which enhances the vascularization of the uterine lining.
- Menstruation -- the periodic shedding of the thickened uterine lining. It occurs when fertilization does not take place.

b) Role of Hormones

The reproductive cycle of the human female involves the interaction of the hormones from the hypothalamus, pituitary gland, and ovaries.

TOPICS	UNDERSTANDINGS	TEACHER NOTES
RD continued	During the menstrual cycle, under the influence of the hormones from the hypothalamus, the pituitary gland releases hormones (FSH and LH) which influence the functioning of the ovaries. The ovaries, in turn, secrete hormones (estrogen and progesterone) which produce changes in the uterus. In addition, the hormones from the ovaries regulate the secretion of hormones by the pituitary gland and the hypothalamus. This is an example of a negative feedback mechanism.	
b. Fertilization	Fertilization usually occurs in the upper portion of the oviduct. If the egg is not fertilized within approximately 24 hours after ovulation, it deteriorates. Cleavage of the fertilized egg begins in the oviduct, and six to 10 days layer, the resulting embryo may become implanted in the uterine lining. If more than one egg is released and fertilized, multiple births may result. Identical twins develop from one zygote which separates during cleavage. Fraternal twins develop from two eggs, each fertilized by separate sperm cells. The technique of *in vitro* fertilization and subsequent implantation that has been perfected in animals has now been applied to humans with some degree of success.	
c. Development		
1) Prenatal Development	Prenatal development includes the following processes: - Cleavage occurs in the oviduct. - Gastrulation usually occurs after the embryo is implanted in the uterus. - Differentiation and growth result in the formation of specialized tissues and organs from the embryonic layers of the gastrula.	

TOPICS	UNDERSTANDINGS	TEACHER NOTES
RD continued	The processes involved in prenatal development are dependent upon the supplying of a proper balance of nutrients to the developing embryo. Some structures associated with prenatal development are: the placenta, amnion, and umbilical cord.	The importance of good nutrition during pregnancy for both the mother and the developing fetus could be mentioned at this time. Teratogens might also be discussed.
2) Birth	Birth usually occurs after a gestation period of approximately nine months.	
3) Postnatal Development	Development continues with various parts of the body growing at different rates. Although the development of the organism is often assumed to conclude with the mature adult, it actually continues throughout the life of the organism and terminates with death. The term aging is applied to the complex developmental changes that occur naturally with the passage of time.	
	The cause or causes of the aging process are still not fully understood. It appears that the aging process results from the interplay of hereditary and environmental factors. One recent definition of death is the irreversible cessation of all brain functions.	Reference may be made to the change in nutritional needs at different stages of the life cycle.
B. Reproduction and Development in Flowering Plants	The processes of meiosis and fertilization occur in the flower, a plant structure specialized for reproduction.	

201

202

TOPICS	UNDERSTANDINGS	TEACHER NOTES
1. Flower Structure	The flower may contain both the male reproductive organ, the stamen, and the female reproductive organ, the pistil. In some species, certain flowers contain only stamens, while others contain only pistils. Petals and sepals may also be present in flowers. The stamen is composed of an anther and filament. As a result of meiosis, the diploid cells of the anther produce pollen grains which contain monoploid nuclei. The pistil is composed of the stigma, style, and the ovary. As a result of meiosis, ovule(s) developing within the ovary contain the monoploid egg nucleus.	
2. Pollination	Pollination is the transfer of pollen grains from the anther to the stigma. Self-pollination is the transfer of pollen from the anther to the stigma of the same flower or to the stigma of another flower on the same plant. Cross-pollination is the transfer of pollen from an anther of one flower to a stigma of a flower on another plant. Cross-pollination is an adaptation which enhances variations. Pollination may be accomplished by wind, insects, and birds. In some instances, the colored petals act as a visual attractant for insects while nectar acts as a chemical attractant. In flowering plants, the problem of reproduction in a dry, external environment is partially solved by the presence of the thick wall of the pollen grain. This prevents dehydration of its contents during its transfer to the female reproductive organ.	

TOPICS	UNDERSTANDINGS	TEACHER NOTES
	Following pollination, the pollen grain germinates on the stigma and forms a pollen tube which extends into the ovule. Sperm nuclei are formed at this time in the pollen tube from the monoploid nucleus in the pollen grain. The pollen tube is an adaptation for internal fertilization.	
3. Fertilization and Embryo Development	The union of male and female nuclei in the ovule results in a zygote.	
	The zygote undergoes development resulting in the formation of the embryo. The ripened ovule develops into the seed. A seed consists of a seed coat, which develops from the outer coverings of the ovule, and an embryo. The ripened ovary develops into the fruit.	
	The plant embryo consists of the hypocotyl, epicotyl, and the cotyledon(s). The hypocotyl develops into the root and, in some species, the lower portion of the stem; the epicotyl develops into the leaves and upper portions of the stem; and the cotyledon(s), which contain stored food, provide the nutrients for the germinating plant.	
4. Germination	In flowering plants, seeds develop inside a fruit. Fruits are specialized structures which aid in seed dispersal.	
	Under suitable environmental conditions, seeds germinate. For most seeds, these conditions include: sufficient moisture, proper temperature, and sufficient oxygen.	
	The development of a seed into a mature plant capable of reproduction involves cell division, differentiation, and growth.	

TOPICS	UNDERSTANDINGS	TEACHER NOTES
5. Growth	Growth in higher plants is restricted largely to specific regions known as meristems. Apical meristems are found in the tips of roots and stems and are responsible for growth in length. Some plants also contain an active lateral meristem region, the cambium, located between the xylem and phloem. This is responsible for the growth in diameter of roots and stems. The growth regions contain undifferentiated cells which undergo active mitotic cell division and elongation. As a result of differentiation, the various tissues and organs are developed.	

Unit V - Transmission of Traits from Generation to Generation

UNIT V — TRANSMISSION OF TRAITS FROM GENERATION TO GENERATION

OBJECTIVES

The student should be able to:

- Explain the transmission of genetic traits using the gene-chromosome theory.
- Predict the probable results of genetic crosses.
- Identify some patterns of inheritance by interpreting pedigree charts.
- List various mutations and describe their consequences.
- List several practical applications of the principles of genetics.
- Recognize the role of heredity and environment in gene expression.
- Describe some techniques used in genetic research.
- Describe some genetically-related disorders in humans.
- Describe the basic structure of the DNA molecule and its assumed role in heredity.
- Explain changes in a population on the basis of the Hardy-Weinberg Principle.

TOPICS	UNDERSTANDINGS	TEACHER NOTES
*I. Foundations of Genetics		
*A. Mendelian Principles	Mendel developed some basic principles of heredity without any knowledge of genes or chromosomes. His principles of dominance, segregation, and independent assortment were established through the mathematical analysis of large numbers of offspring produced by crossing pea plants.	

TOPICS	UNDERSTANDINGS	TEACHER NOTES
	As a result of analyzing specific mathematical ratios associated with certain characteristics in the offspring, Mendel proposed that characteristics were inherited as a result of the transmission of hereditary factors.	
B. Gene-Chromosome Theory	The significance of Mendel's work was not immediately recognized. After his work was rediscovered, evidence from the microscopic study of dividing cells and breeding experiments with Drosophila enabled scientists to link the presence of chromosomes and their migration during meiosis with the hereditary factors which Mendel proposed in his principles. Mendel's hereditary factors, now called genes, exist at definite loci in a linear fashion on chromosomes. Two genes associated with a specific characteristic are known as alleles and are located on homologous chromosomes. The gene-chromosome theory provides the mechanism to account for the hereditary patterns which Mendel observed.	
*II. Some Major Genetic Concepts		
*A. Dominance	In some patterns of heredity, if only one of the genes in an allelic pair is expressed, it is called a dominant allele; the gene which is present but not expressed is called the recessive allele. By convention, a capital letter symbolizes a dominant allele. The lower case form of the same letter symbolizes the recessive allele. For example, in certain pea plants, the allele for tallness (T) is dominant and the allele for shortness (t) is recessive. If two genes of an allelic pair are the same, the genetic makeup, genotype, is said to be homozygous (TT or tt).	213

If two genes of an allelic pair are different, the genetic makeup is said to be heterozygous or hybrid (Tt).

When an individual homozygous for the dominant trait is crossed with an individual homozygous for the recessive trait, the appearance (phenotype) of the offspring, known as the F_1 generation, is like that of the dominant parent. The genotype of these offspring is heterozygous.

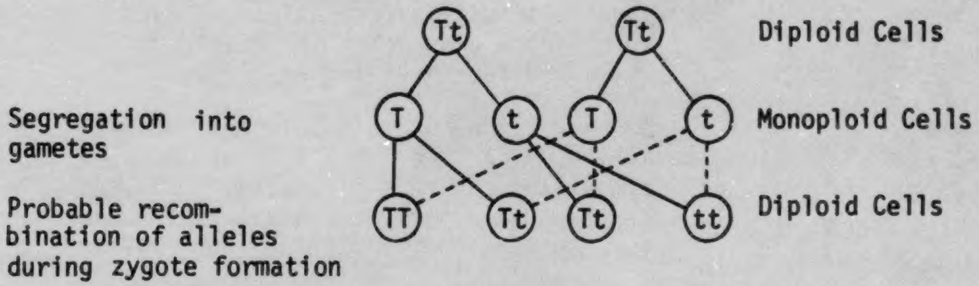
Offspring resulting from the cross between members of the F_1 generation comprise the F_2 generation.

*B. Segregation and Recombination

When gametes are formed during meiosis there is a random segregation of homologous chromosomes.

As a result of fertilization, alleles recombine. As a consequence, new allelic gene combinations are likely to be produced.

Segregation and recombination is illustrated by the following diagram which represents the cross between two individuals heterozygous for tallness.


Tt
Tt
Diploid Cells
Segregation into gametes
T
t
T
t
Monoploid Cells
Probable recombination of alleles during zygote formation
TT
Tt
Tt
tt
Diploid Cells

214

215

Assuming large numbers of such crosses, the phenotypic ratio of tall offspring to short offspring is 3:1 and the genotypic ratio of homozygous tall offspring to heterozygous tall offspring to homozygous recessive offspring is 1:2:1.

To determine the genotype of an individual showing the dominant phenotype, it is crossed with a homozygous-recessive individual. Recessive phenotypes among the offspring indicate a heterozygous parent. This procedure is known as a test cross.

C. Intermediate Inheritance

Sometimes traits are not clearly dominant or recessive due to the complex nature of gene action. In intermediate inheritance, the heterozygous offspring are phenotypically different than their homozygous parents. There are different degrees of intermediate inheritance. One is codominance.

Codominance involves the expression of two dominant alleles. This results in the simultaneous expression of both alleles in the phenotype of the heterozygous individual. For example, in the inheritance of coat color in roan cattle, the following symbols can be used: C^RC^R represents the genotype of the homozygous red coat. C^WC^W represents the genotype of the homozygous white coat. C^RC^W represents the genotype of the heterozygous roan coat. The coat of the roan animal is composed of a mixture of red and white hairs.

Examples of codominance in humans are sickle-cell anemia and blood groups.

In all instances of intermediate inheritance, the F_2 offspring of heterozygous parents exhibit a 1:2:1 phenotypic ratio.

As molecular genetics and classical genetics begin to merge, long held concepts of classical genetics become less definitive. The actual interactions of gene products shed new light on our concepts of dominance and recessiveness. Dominance and recessiveness may, in fact, be relative terms.

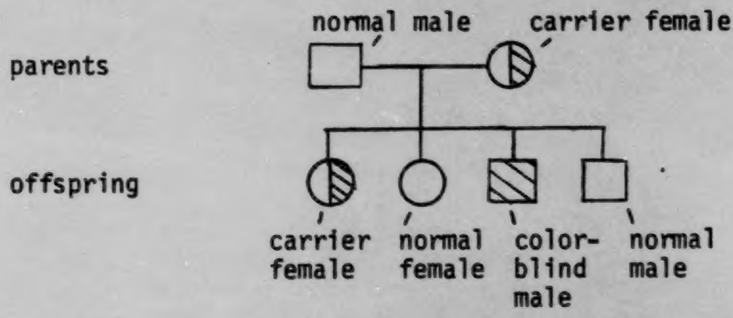
Incomplete or partial dominance as exhibited by pink snapdragons and four o'clocks is another type of intermediate inheritance in which the

TOPICS	UNDERSTANDINGS	TEACHER NOTES
D. Independent Assortment	If the genes for two different traits are located on different chromosome pairs (nonhomologous chromosomes), they segregate randomly during meiosis and, therefore, may be inherited independently of each other.	heterozygous individuals exhibit a phenotype intermediate between either homozygous parent.
E. Gene Linkage	If the genes for two different traits (nonallelic genes) are located on the same chromosome pair (homologous chromosomes) they are said to be linked and, therefore, are usually inherited together.	
F. Crossing Over	During synapsis in the first meiotic division, the chromatids in a homologous pair of chromosomes often twist around each other, break, exchange segments, and rejoin. This results in a rearrangement of linked genes and increases the variability of offspring.	
G. Multiple Alleles	In some instances, an observed pattern of heredity can not be explained on the basis of a single pair of alleles. Experimental evidence indicates that in such patterns multiple alleles are involved. In this pattern no more than two of these alleles for the given trait may be present within each cell. In a population of humans, the inheritance of the ABO blood group may be explained using a model that employs three alleles (I^A, I^B and i). In this model, alleles I^A and I^B are codominant with each other and i is recessive to both I^A and I^B. Genotypes associated with each blood type in the ABO group are:	

Blood Type	Genotype
A	I^AI^A OR I^Ai
B	I^BI^B OR I^Bi
AB	I^AI^B
O	ii

218

219

TOPICS	UNDERSTANDINGS	TEACHER NOTES
H. Sex Determination	Diploid cells of many organisms contain two types of chromosomes: autosomes and sex chromosomes. In each human cell, there are 22 pairs of autosomes and one pair of sex chromosomes. The sex chromosomes are designated as "X" and "Y." The XX condition produces females,and the XY condition produces males. The sex of a human is genetically determined at fertilization when a sperm cell containing either an X or Y chromosome unites with an egg cell containing an X chromosome.	
I. Sex Linkage	Morgan's work with Drosophila demonstrated that genes for certain traits are located on the X chromosomes. These genes are said to be sex-linked and do not appear to have corresponding alleles on the Y chromosome. Since many sex-linked genes are recessive, they are expressed more frequently in males than in females. Hemophilia and color-blindness are examples of sex-linked traits in humans.  normal male carrier female parents offspring carrier female normal female color-blind male normal male	
*III. Mutations	Changes in the genetic material are called mutations. If these mutations occur in sex cells they may be transmitted to the next generation.	

TOPICS	UNDERSTANDINGS	TEACHER NOTES
	Mutations occurring only in the body cells may be perpetuated in the individual but will not be passed on to the offspring by sexual reproduction.	
*A. Types	Mutations may be classified as chromosomal alterations or gene mutations.	
1. Chromosomal Alterations	A chromosomal alteration is a change in the number of chromosomes or in the structure of the chromosomes.	
	The effects of chromosomal alterations are often visible in the phenotype of an organism because many genes are usually involved.	
a. Change in Chromosome Number	During meiosis, homologous chromosomes separate from each other. This separation is known as disjunction. Sometimes a pair of homologous chromosomes fails to separate from each other (nondisjunction). This results in gametes with more (or less) than their normal (n) chromosome number. If these gametes are involved in fertilization, the resulting zygote may have more (or less) than the normal (2n) chromosome number.	
	For example, in humans, Down's syndrome usually results from the possession of an extra chromosome. This is due to the nondisjunction of chromosome number 21 in one of the parents.	Discussion of maternal age risks might be included.
	Occasionally, the disjunction of a complete set of chromosomes (2n) fails to occur during gamete formation. The resulting 2n gamete sometimes fuses with a normal n gamete, producing a 3n zygote. If two 2n gametes fuse, a 4n zygote results. The possession of extra sets of chromosomes is known as a polyploid condition. This is rather common in plants but rare in animals.	

TOPICS	UNDERSTANDINGS	TEACHER NOTES
	In plants, some polyploid individuals are usually larger or more vigorous than diploid varieties. Some polyploid individuals are sterile (seedless).	Examples include strains of cotton, wheat, potatoes, alfalfa, apples, tobacco and zinnias. Polyploid watermelons are nearly seedless.
b. Change in Chromosome Structure	Alterations in chromosome composition may result from random breakage and recombination of chromosome parts.	
	MG Some examples of changes in chromosome structure are: - Translocation -- the transfer of a section of one chromosome to a nonhomologous chromosome - Additions and deletions -- the loss or gain of a portion of a chromosome.	
2. Gene Mutations	A gene mutation involves a random change in the chemical nature of the genetic material (DNA). While the effects of some gene mutations, such as albinism, are obvious, the effects of other gene mutations may not be as readily noticed. The adaptive value of a gene mutation is dependent upon the nature of the mutation and the type of environment with which the organism interacts.	
*B. Mutagenic Agents	Although mutations may occur spontaneously, their incidence may be increased by such agents as: - Radiation -- x-rays, ultraviolet, radioactive substances,and cosmic rays - Chemicals -- formaldehyde, benzene, and asbestos fibers.	

TOPICS	UNDERSTANDINGS	TEACHER NOTES
IV. Genetic Applications to Animal and Plant Breeding	Artificial selection,including inbreeding and hybridization, and the maintenance of desirable mutations by vegetative means are methods used by scientists to improve, produce, and maintain new varieties of animals and plants.	Illustrate genetic applications by using examples such as seedless oranges, hybrid roses, apple varieties, breeds of dogs, cattle, and horses.
V. Interaction of Heredity and Environment	The environment interacts with genes in the development and expression of inherited traits. The relationship between gene action and environmental influence has been studied in many organisms. Examples include: - Effect of light on chlorophyll production - The effect of temperature on hair color in the Himalayan rabbit - Identical twin studies.	
VI. Human Heredity	The principles of genetics appear to hold for all organisms including humans. The acquisition of knowledge of human genetics has been limited because humans are not suitable subjects for experimentation. An increased knowledge of human genetics has resulted from the expansion of the field of genetic counseling.	
MG		
	Human genetic disorders are often detected through genetic counseling and the use of the following techniques.	
A. Techniques for Detection	The presence of many genetic disorders can be detected either before or after birth. In some instances, carriers of genetically-related disorders may also be identified.	

TOPICS	UNDERSTANDINGS	TEACHER NOTES
MG continued	Some of these techniques include: - Screening -- chemical analysis of body fluids such as blood and urine - Karyotyping -- the preparation of an enlarged photograph showing paired homologous chromosomes from a cell - Amniocentesis -- the removal of amniotic fluid for chemical and/or cellular analysis.	
B. Genetically Related Disorders	Some genetically related disorders in humans include phenylketonuria, sickle-cell anemia,and Tay-Sachs.	
1. Phenylketonuria (PKU)	PKU is a condition characterized by the development of mental retardation and has been shown to occur when an individual is homozygous with respect to a recessive mutant gene. The symptoms of the disorder apparently result from the inability of a gene to synthesize a single enzyme necessary for the normal metabolism of phenylalanine. Urine analysis of newborns allows for proper dietary treatment to prevent the mental retardation associated with this disorder.	
2. Sickle-Cell Anemia	Sickle-cell anemia is a homozygous condition resulting in the formation of abnormal hemoglobin and sickled red blood cells. It is characterized by severe pain due to obstructed blood vessels and anemia caused by the fragility of red blood cells. This disorder is more likely to occur among individuals of African descent. Heterozygous and homozygous individuals may be detected by blood screening. An afflicted fetus may be detected by anmniocentesis.	
3. Tay-Sachs	Tay-Sachs is a recessive genetic disorder characterized by the malfunctioning of the nervous system, caused by the deterioration of nervous tissue. This deterioration is due to the accumulation of fatty material as a result of the inability to synthesize a specific enzyme. This fatal disorder is more likely to occur among Jewish people of Central European descent.	

TOPICS | UNDERSTANDINGS | TEACHER NOTES

Carriers may be detected through blood screening. Chemical analysis of amnionic fluid can detect an afflicted fetus.

*VII. Modern Genetics

*A. DNA as the Hereditary Material

In recent years, biochemists have found that deoxyribonucleic acid is the genetic material which replicates and is passed from generation to generation. DNA controls cellular activity by influencing the production of enzymes.

In order to understand the chemical nature of the gene, the chemical structure of nucleic acids must be understood.

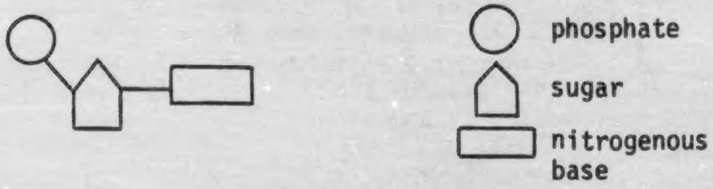
*1. DNA Structure

DNA, found in the nucleus of cells, is a polymer. It is a very large molecule consisting of thousands of smaller, repeating units known as nucleotides.

a. DNA Nucleotide

A DNA nucleotide is composed of three parts:
- A phosphate group
- A deoxyribose (5-carbon sugar) molecule
- A nitrogenous base of either adenine, thymine, guanine, or cytosine.

A nucleotide may be represented as follows:



TOPICS	UNDERSTANDINGS	TEACHER NOTES
b. Watson-Crick Model	Watson and Crick developed a model of the DNA molecule. In this model the DNA molecule consists of two complementary chains of nucleotides. - The DNA molecule has a "ladder" type organization. The uprights of the "ladder" are composed of alternating phosphate and deoxyribose molecules. Each rung of the "ladder" is composed of bases held together by relatively weak hydrogen bonds. Base pair combinations are restricted to: adenine (A)- thymine (T), and guanine (G)- cytosine (C). - This "ladder" is thought to be twisted in the form of a double helix.	
MG		
	The Watson-Crick model can be used to explain the principal actions of genes: - Maintaining genetic continuity by means of replication - Controlling cellular activity by controlling production of specific enzymes.	
2. DNA Replication	DNA is believed to replicate in the following manner during the processes of mitosis and meiosis. - Double-stranded DNA unwinds and "unzips" along weak hydrogen bonds between the base pairs. - Free nucleotides in the nucleus are incorporated, in sequence, forming two double strands of DNA which are identical to each other and to the original DNA molecule.	
3. Gene Control of Cellular Activities	The control of cellular activities involves both DNA and RNA.	
a. RNA	RNA, like DNA, is composed of nucleotide building blocks. However, there are three major differences between the structure of DNA and RNA molecules. In RNA:	

TOPICS	UNDERSTANDINGS	TEACHER NOTES
MG continued	- ribose is substituted for deoxyribose. - uracil is substituted for thymine. - there is a single chain of nucleotides. There are three types of RNA: messenger RNA, transfer RNA, and ribosomal RNA.	
b. Genetic Code	Evidence strongly suggests that a genetic code exists. This code contains the information for the sequence of amino acids in a particular protein. The code is present in messenger RNA molecules which are complementary to DNA molecules. The RNA code is a triplet code (codon) based on various sequences of three bases in the messenger RNA molecule.	
c. Protein Synthesis	DNA serves as a template for the synthesis of messenger RNA from free RNA nucleotides. The messenger RNA molecules, carrying a specific code determined by the base sequence of the original DNA molecules, move from the nucleus to the cytoplasm where they become associated with ribosomes composed in part of ribosomal RNA. Specific transfer RNA molecules pick up and transfer to the ribosomes specific amino acid molecules found in the cytoplasm. At the ribosomes, each specific transfer RNA molecule bonds to a particular codon. Particular polypeptide chains are formed as the amino acids associated with the transfer RNA molecules are bonded in a sequence determined by the base sequence of the messenger RNA.	It is thought that ribosomal RNA temporarily binds messenger RNA to the ribosomes.
d. The "One Gene-One Polypeptide Hypothesis"	A hypothesis called the "one gene-one enzyme hypothesis" proposed that the synthesis of each enzyme in a cell was governed by the action of a single gene (a specific sequence of DNA nucleotides.) However, the name of this hypothesis has been changed to the one gene- one polypeptide hypothesis since it is now known that a single enzyme may be composed of several polypeptides and a synthesis of each polypeptide is governed by a different gene.	

TOPICS	UNDERSTANDINGS	TEACHER NOTES
MG continued	A modern definition of the gene is the sequence of nucleotides in a DNA necessary to synthesize a polypeptide.	
e. Individuality of Organisms as Related to Their DNA.	Since the sequence of nucleotides in DNA determines the sequence of nucleotides in messenger RNA, DNA ultimately determines the sequence of the amino acids in specific proteins. The specificity of enzymes is dependent on their protein makeup, and, since the individuality of a cell is largely a function of the enzymes it possesses, it is evident that DNA determines the individuality of an organism.	
f. Gene Mutations		
1) Description	Gene mutations may be interpreted biochemically as any change in the base sequence of an organism's DNA.	
2) Types	Gene mutations include the addition and/or deletion of bases in the DNA sequence, as well as the substitution of one base for another base in the DNA sequence.	
B. Genetic Research		
1. Cloning	Cloning is the process of producing a group of genetically identical offspring from the cells of an organism. This technique shows great promise in agriculture. Plants with desirable qualities can be rapidly produced from the cells of a single plant. The cloning of animals is still in the early stages of research.	
2. Genetic Engineering	Genetic information may be transferred from one organism to another, resulting in the formation of recombinant DNA. New genes can be introduced into an organism as a result of this transfer. The cell can then synthesize the chemical coded for by these new genes. Examples of these chemicals include: insulin, interferon, and human growth hormone.	

TOPICS	UNDERSTANDINGS	TEACHER NOTES
MG continued	Such genetic engineering has potential for the correction of genetic defects and the development of agriculturally desirable plants and animals.	
*C. Population Genetics	The study of factors which affect gene frequencies in populations of sexually reproducing organisms is known as population genetics.	
1. Population	A population includes all members of a species inhabiting a given location.	
2. Gene Pool	The gene pool of a population consists of the sum total of all the heritable genes for the traits in a given population.	
3. Gene Frequency	The gene frequency is the percentage of each allele for a particular trait in a population.	
4. The Hardy-Weinberg Principle	Hardy and Weinberg studied populations of sexually reproducing individuals. Their studies resulted in the formulation of the Hardy-Weinberg Principle. This principle states that the gene pool of a population tends to remain stable (i.e., gene frequencies remain constant) if certain conditions are met. These conditions for gene pool stability include: - Large populations - Random mating - No migration - No mutation The stability of a population suggested by the Hardy-Weinberg Principle rarely occurs since some or all of the conditions for gene pool stability may not be met. The unstable gene pool that results tends to produce change in the population.	

Unit VI - Evolution

UNIT VI — EVOLUTION

OBJECTIVES

The student should be able to:

- Understand that evolution is a process of change.
- Recognize that evolutionary theory is supported by observations and inferences from many branches of science.
- Describe some of the supporting data for evolutionary theory.
- Discuss the historical development of evolutionary theory.
- Describe a hypothesis which attempts to explain how primitive environmental conditions may have contributed to the formation of initial life forms.

TOPICS	UNDERSTANDINGS	TEACHER NOTES
I. Evolution	Evolution is a process of change through time.	As part of the introduction of this unit, it is appropriate to explain that the theory of evolution, as is the case with other scientific theories, has been and continues to be subjected to verification by scientific processes. Further, the teacher should briefly mention that there are supernatural accounts of origins which are classified as being
*II. Evolution Theory	Evolution theory is a unifying principle for the biological sciences. It provides an explanation for the differences in structure, function, and behavior among life forms. Evolution includes the change in characteristics of populations through generations. Thus, existing life forms have evolved from earlier life forms.	
*A. Supporting Observations	Observations supporting the theory of organic evolution can be made through the study of the geologic record and comparative studies in the fields of cytology, biochemistry, anatomy, and embryology.	

241

242

TOPICS	UNDERSTANDINGS	TEACHER NOTES
1. Geologic Record	Geologists have dated the earth to be between four and one-half and five billion years old. This age was determined by radioactive dating of rocks. It is assumed that the earth is at least as old as the oldest rocks and minerals composing its crust.	outside the domain of science because they are beyond the scope of scientific investigation. Therefore, these accounts are not part of this course of study. (See pp. 137-138)
	Fossils are the direct or indirect remains of organisms preserved in media such as sedimentary rock, amber, ice,or tar.	
	Fossils have been found which indicate that organisms existed over three billion years ago.	Fossils of prokaryotic life forms indicate an age of 3.4 billion years or greater. (Fig-Tree chert of South Africa.)
	Upper, undisturbed strata generally contain fossils of more complex organisms, whereas, the lower strata contain fossils of simplier life forms.	
	When comparing fossils in undisturbed strata, fossils can be found in upper strata which, although different from fossils in lower strata, resemble those fossils. This suggests links between modern forms and older forms, as well as divergent pathways from common ancestors.	
2. Comparative Cytology	The cell is the unifying structure for living things. Organelles such as the plasma membrane, ribosomes, and mitochondria, are structurally and functionally similar in most divergent organisms.	
3. Comparative Biochemistry	Nucleic acids, their structure and function, are similar in living organisms.	
	Many different organisms have similar proteins and enzymes.	
	The closer the relationship among organisms, the greater their biochemical similarity, thus suggesting evolutionary relationships.	

TOPICS	UNDERSTANDINGS	TEACHER NOTES
4. Comparative Anatomy	A comparative study of certain organisms indicates similarities in anatomical features. Homologous structures are anatomical parts that are similar in structure and origin although they may function differently. Homologous bones exist in the forelimbs of many different vertebrates such as frogs, birds, bats, horses, whales, and humans.	
5. Comparative Embryology	Comparison of early embryonic development among groups of organisms reveals similarities which suggest common ancestry. Early vertebrate embryos closely resemble one another. As development proceeds, the distinctive traits of each species become apparent.	
*B. Theories of Evolution	Theories of evolution are attempts to explain the diversities among species. Adaptations are a major component of these theories. Adaptations are features (structure, function, or behavior) which make a species better suited to live and reproduce in its environment.	Explanations of evolution should be taught as theories rather than as unchanging dogma. Past and current revisions of evolutionary theory indicate the willingness of scientists to modify theory on the basis of new evidence.
1. Lamarck	Lamarck's theory encompassed two main ideas: - Use and Disuse -- New organs arise according to the needs of an organism and the size of organs is determined by the degree to which they are used. - Transmission of Acquired Characteristics -- useful characteristics acquired by an individual during its lifetime can be transmitted to its offspring. These acquired characteristics result in species better adapted to their environment. Weismann's experiments involving the removal of the tails of mice over several generations helped to disprove Lamarck's theory of the inheritance of acquired characteristics.	

TOPICS	UNDERSTANDINGS	TEACHER NOTES
2. Darwin	Darwin's theory of evolution was based on variation and natural selection. It encompassed the following ideas: - Overproduction -- Within a population more offspring are born than can possibly survive. - Competition -- Since the number of individuals in a population tends to remain constant from generation to generation, a struggle for survival is suggested. - Survival of the Fittest -- The individuals who survive are the ones best adapted to exist in their environment due to the possession of variations that maximize their fitness. - Reproduction -- Individuals that survive and then reproduce transmit these variations to their offspring. - Speciation -- As time and generations continue, adaptations are perpetuated in individuals and new species evolve from a common ancestral species.	
	Darwin's theory of natural selection did not explain the genetic basis for variations.	
*3. Modern Evolutionary Theory	The modern theory of evolution supports Darwin's concepts of variation and natural selection and incorporates the genetic basis of variation in individual organisms and populations.	
*a. Producing Variation	The genetic basis for variation within a species is provided by mutations and sexual reproduction.	
	Mutations are spontaneous and provide the raw material for evolution.	
	Sexual reproduction involves the sorting out and recombination of genes, thus producing and maintaining variations.	

TOPICS	UNDERSTANDINGS	TEACHER NOTES
b. Natural Selection	Natural selection involves the struggle of organisms to survive and reproduce in a given environment. Traits which are beneficial to the survival of an organism in a particular environment tend to be retained and passed on, and, therefore, increase in frequency within a population. Traits which have low survival value to organisms tend to diminish in frequency from generation to generation. If environmental conditions change, traits that were formerly associated with a low survival value may, in a changed environment, have greater survival value and increase accordingly. Examples include: - Roaches, mosquitoes, and houseflies resistant to insecticides. (Resistance is not in response to the insecticide. The insecticide acts as a selecting agent.) - Penicillin-resistant strains of microorganisms.	
1) Geographic Isolation	Geographic isolation favors speciation by segregating a small group from the main population. Changes in gene frequencies are more likely in small populations than in large populations.	
	In time, this isolated population may evolve into separate species due to the following factor(s): - It may have possessed different initial gene frequencies than the main population. - Different mutations occur within the main population and the isolated population. - Different environmental factors, and thus, different selection pressures, may be acting on each population.	It is probable that initially the isolated population had a different gene frequency than the original population. This is the Founder Effect.

TOPICS	UNDERSTANDINGS	TEACHER NOTES
	Examples include Darwin's finches on the Galapagos Islands, and marsupials in Australia.	
2) Reproductive Isolation	These separated groups may become so divergent that, if geographic barriers were removed, interbreeding could not take place. Thus, the two populations have become reproductively isolated and have become two distinct species.	
c. Time Frame for Evolution	While the essentials of Darwin's theory of evolution, variation, and natural selection are generally accepted within the scientific community, considerable discussion exists within this community as to the time frame in which evolution occurs. Gradualism and Punctuated Equilibrium are attempts by scientists to address the question of the rate of evolution.	
1) Gradualism	Gradualism proposes that evolutionary change is slow, gradual, and continuous.	
2) Punctuated Equilibrium	Punctuated Equilibrium proposes that species have long periods of stability (typically several million years) interrupted by geologically brief periods of significant change during which new species may evolve.	According to some scientists, geologically brief periods represent approximately one percent of the duration of a species. The fossil record indicates that most invertebrate species have an average duration of 5-10 million years.

TOPICS	UNDERSTANDINGS	TEACHER NOTES
*III. Heterotroph Hypothesis	Some scientists have proposed the heterotroph hypothesis as an explanation for how early life forms may have developed on the primitive earth. According to this hypothesis, the first life forms were not able to synthesize their own organic nutrients from inorganic compounds.	Like many scientific explanations of incompletely understood phenomena, the heterotroph hypothesis is based upon logical extensions of certain basic assumptions.
A. Primitive Life Forms		
1. Raw Materials	It is assumed that the primitive earth was an exceptionally hot body consisting of inorganic substances in solid, liquid, and gaseous states, with a rich supply of energy in the environment.	
a. Matter	Water, condensing and falling as rain, carried dissolved atmospheric gases (ammonia, methane, and hydrogen) and minerals into the seas, forming a "hot, thin soup."	
b. Energy Sources	In addition to heat, energy in the form of lightning, solar radiation (including x-rays and ultraviolet rays), and radioactive materials in the rocks, provided an energy rich environment.	
2. Synthesis	Energy from the environment contributed to the formation of chemical bonds among the dissolved particles in the "hot, thin soup" of the seas. This type of synthesis led to the formation of organic molecules such as simple sugars and amino acids. Experiments by Miller have simulated the primitive environment in the laboratory and have resulted in the production of organic compounds.	

TOPICS	UNDERSTANDINGS	TEACHER NOTES
	In time, these organic molecules interacted and formed more complex organic molecules.	
	Experiments by Fox have demonstrated interactions among these organic molecules.	
3. Nutrition	Some of the large, complex molecules formed aggregates. These aggregates probably incorporated molecules from the seas as "food," thus carrying on heterotrophic nutrition.	
4. Reproduction	In time, as these aggregates became increasingly complex and highly organized, the ability to reproduce evolved. These aggregates are considered to have been alive when they developed the ability to reproduce.	
B. Heterotroph to Autotroph	It is thought that these heterotrophs evolved a pattern of respiration similar to the anaerobic process of fermentation. Extended periods of fermentative activity by these organisms added quantities of carbon dioxide to the environment.	
	Some heterotrophs evolved a means of using the carbon dioxide to synthesize organic compounds. These were the pioneer autotrophs.	
C. Anaerobe to Aerobe	Autotrophic activity added free oxygen to the environment.	
	Some autotrophs and heterotrophs evolved mechanisms by which they used this oxygen to derive energy.	
	Present day organisms may be heterotrophic or autotrophic; aerobic or anaerobic.	

Unit VII - Ecology

UNIT VII — ECOLOGY

OBJECTIVES

The student should be able to:

- Describe the interdependency of organisms on each other and on their environment.
- Identify and define the ecological levels of organization of the living world.
- Identify and describe the components that form and maintain an ecosystem.
- Explain how interactions of living organisms with each other and their environment result in succession.
- Assess human influence on the balance of nature.

TOPICS	UNDERSTANDINGS	TEACHER NOTES
I. Ecology	Ecology is the study of the interactions among organisms and their interrelationships with the physical environment. No organism exists as an entity, separate and distinct from its environment.	
II. Ecological Organization		
A. Population	A population is all the members of a species inhabiting a given location.	
B. Community	All the interacting populations in a given area represent a community.	
C. Ecosystem	An ecosystem is the living community and the physical environment functioning together as an interdependent and relatively stable system.	
D. Biosphere	The biosphere is the portion of the earth in which life exists. It is composed of numerous complex ecosystems.	

TOPICS	UNDERSTANDINGS	TEACHER NOTES
III. Ecosystems	The ecosystem is the structural and functional unit studied in ecology.	
A. Ecosystem Structure and Function	An ecosystem involves interactions between abiotic and biotic factors. An ecosystem is a self-sustaining unit if the following requirements are met: - A constant source of energy and a living system capable of incorporating this energy into organic compounds - A cycling of materials between organisms and their environment	
1. Components	Components of the ecosystem involve interacting abiotic and biotic factors.	
*a. Abiotic Factors	The abiotic environment includes physical and chemical factors which affect the ability of organisms to live and reproduce. The abiotic factors include: - Intensity of light - Range of temperatures - Amount of moisture - Type of substratum - Availability of inorganic substances such as minerals - Supply of gases such as O_2, CO_2, N_2. - pH Each of these factors varies in the environment and, as such, may act as a limiting factor, determining the types of organisms which may exist in that environment. Examples include: - A low annual temperature common to the northern latitudes determines in part what species of plants can exist in that area.	

TOPICS	UNDERSTANDINGS	TEACHER NOTES
	- The amount of oxygen dissolved in a body of water will help determine which species of fish will exist there. - The salt-laden air and water of coastal areas limit what species can exist in those regions.	
b. Biotic Factors	Biotic factors are all the living things that directly, or indirectly, affect the environment. Thus, the organisms, their presence, parts, interaction, and wastes, all act as biotic factors. Biotic factors interact in many ways such as in nutritional relationships and symbiotic relationships.	
1) Nutritional Relationships	Nutritional relationships involve the transfer of nutrients from one organism to another within an ecosystem.	
a) Autotrophs	These organisms can synthesize their own food from inorganic compounds and a usable energy source.	
*b) Heterotrophs	These organisms cannot synthesize their own food and are dependent upon other organisms for food. On the basis of this dependency, organisms are classified as either saprophytes, herbivores, carnivores, or omnivores.	The use of local examples is encouraged.
(1) Saprophytes	Saprophytes include those heterotrophic plants, fungi, and bacteria which live on dead matter.	
(2) Herbivores	Herbivores are those animals which consume plants.	
(3) Carnivores	Carnivores are those animals which consume other animals. These include: - Predators -- animals which kill and consume their prey.	

TOPICS	UNDERSTANDINGS	TEACHER NOTES
	- Scavengers -- animals which feed on other animals they have not killed.	
(4) Omnivores	Omnivores are those animals that consume both plants and animals.	
EC 2) Symbiotic Relationships	Different organisms may live together in a close association. This living together in close association is known as symbiosis. Symbiotic relationships may or may not be beneficial to the organisms involved. Types of symbiosis include:	Symbiotic relationships may include: nutritional, reproductive, and protective relationships.
a) Commensalism	In this relationship one organism is benefited and the other is not adversely affected. (+,0). Examples include: barnacles on whales, and orchids on large tropical trees.	
b) Mutualism	In this relationship both organisms benefit from the association. (+,+). Examples include: nitrogen-fixing bacteria within the nodules of legumes, and certain protozoa within termites.	
c) Parasitism	In this relationship, the parasite benefits at the expense of the host. (+,-). Examples include: athlete's foot fungus on humans, and tapeworm and heartworm in dogs.	Recent experimental researcn indicates that lichens may represent a controlled parasitic relationship of the fungus on an algal host.
2. Energy Flow Relationships	If an ecosystem is to be self-sustaining it must contain a flow of energy.	
a. Energy Flow	Those life activities which are characteristic of living organisms require the expenditure of energy.	

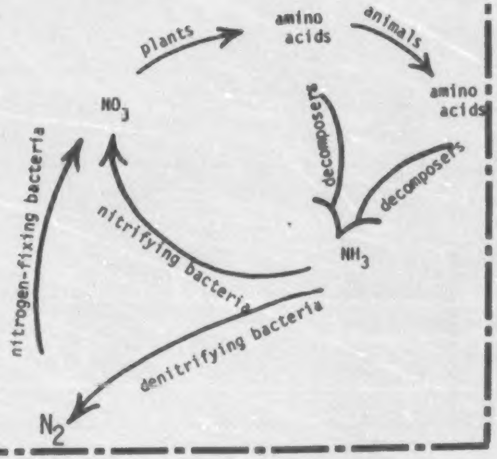
TOPICS	UNDERSTANDINGS	TEACHER NOTES
	The pathways of energy through the living components of an ecosystem are represented by food chains and food webs.	
b. Food Chain	Green plants convert radiant energy from the sun into chemical energy (food). A food chain involves the transfer of energy from green plants through a series of organisms with repeated stages of eating and being eaten.	
c. Food Web	In a natural community, the flow of energy and materials is much more complicated than is illustrated by any one food chain. Since practically all organisms may be consumed by more than one species, many interactions occur among the food chains of any community. These interactions are described as a food web. Interactions in a food web involve:	
1) Producers	The energy for a community is derived from the organic compounds synthesized by green plants. Autotrophs are therefore considered the producers.	
2) Consumers	Organisms that feed directly upon green plants are primary consumers or herbivores. Secondary consumers, or carnivores, feed upon other consumers. Omnivores may be either primary or secondary consumers.	
3) Decomposers	Organic wastes and dead organisms are eventually broken down to simpler substances by decomposers, such as the bacteria of decay. Through this action, chemical substances are returned to the environment where they can be used by other living organisms.	
d. Pyramid of Energy	There is much more energy at the producer level in a food web than at the consumer levels, and there is more energy at the primary consumer level than at the secondary consumer level. A pyramid of energy can be used to illustrate the loss of usable energy at each feeding level.	

TOPICS	UNDERSTANDINGS	TEACHER NOTES
	Each consumer level of the food pyramid utilizes approximately 10 percent of its ingested nutrients to build new tissue. This new tissue represents the food for the next feeding level. The remaining energy is lost in the form of heat and unavailable chemical energy. Eventually, the energy in an ecosystem is lost and is radiated from the earth's system. Thus, an ecosystem cannot sustain itself without the constant input of energy from the sun.	
EC e. Biomass Pyramid	In general, the decrease of energy at each successive feeding level means that less biomass (amount of organic matter) can be supported at each level. Thus, the total mass of carnivores in a particular ecosystem is less than the total mass of the producers. The decrease of biomass at each feeding level is illustrated by a pyramid of biomass.	Reference might be made to the lack of meat in the diet of humans in some overpopulated countries.
3. Material Cycles	In a self-sustaining ecosystem, material must be cycled among the organisms and the abiotic environment. Thus, the same materials can be reused.	
a. Carbon-Hydrogen-Oxygen Cycle	The carbon-hydrogen-oxygen cycle involves the processes of respiration and photosynthesis.	
b. Water Cycle	The water cycle involves the processes of photosynthesis, transpiration, evaporation and condensation, respiration, and excretion.	Reference might be made to acid rain which is discussed on page 133 of the syllabus.
c. Nitrogen Cycle	The nitrogen cycle is an example of a material cycle involving decomposers and other soil bacteria which, in part, break down and convert nitrogenous wastes and the remains of dead organisms into materials usable by autotrophs.	

EC

- Atmospheric nitrogen is converted into nitrates by nitrogen-fixing bacteria.
- Plants use nitrates for protein synthesis.
- Animals which eat plants convert the plant protein into animal protein.
- Nitrogenous wastes and the bodies of dead plants and animals are broken down by decomposers and ammonia is released.
- Ammonia may be converted into nitrates by nitrifying bacteria.
- Nitrogen containing compounds may also be broken down by denitrifying bacteria, resulting in the release of nitrogen into the atmosphere.

A summary of the nitrogen cycle could be represented by:


plants
amino acids
animals
amino acids
NO_3
decomposers
decomposers
nitrogen-fixing bacteria
nitrifying bacteria
NH_3
denitrifying bacteria
N_2

*B. Ecosystem Formation

Ecosystems tend to change with time until a stable system is formed. The type of ecosystem that is formed depends on the climatic limitations of a particular geographical area.

*1. Succession

The replacement of one community by another until a stable stage (climax) is reached is called ecological succession.

EC a. Pioneer Organisms

Succession may be said to begin with pioneer organisms, since these are the first plants to populate a given location. Lichens, for example, are the pioneer organisms on bare rock.

Pioneer organisms modify their environment. Seasonal dieback and erosion, for example, would create pockets of "soil" in the crevices and hollows on the bare rock.

TOPICS	UNDERSTANDINGS	TEACHER NOTES
EC continued		
b. Changes	Each community modifies the environment, often making it more unfavorable for itself and, apparently, more favorable for the following community which infiltrates the first community over a period of years.	Reference might be made to changes in the humus and moisture levels of the soil.
	A typical successional sequence in New York State might be: pioneer, grass, shrub, conifer, and deciduous woodland.	Local examples should be included.
	Plant species (flora) dominate in the sense that they are the most abundant food sources. Plant succession is a major limiting factor for animal (fauna) succession.	
	Communities are composed of populations able to exist under the prevailing conditions and are identified by their dominant plant species -- the one that exerts the most influence over the other species present.	Some examples include: Pine Barrens and Sphagnum Bog.
c. Climax Community	A climax community is a self-perpetuating community in which populations remain stable and exist in balance with each other and the environment. A climax community persists until a catastrophic change of a major abiotic or biotic nature alters or destroys it, thus producing non-climax conditions.	
	Thereafter, succession once again occurs leading to a climax community. The original climax community may be reestablished or a new climax may be established if the abiotic environment has been permanently altered.	Examples include: forest fires, abandoned farmlands, and areas where topsoil has been removed.
	The oak-hickory and the hemlock-beech-maple associations represent two climax communities found in New York State.	

TOPICS	UNDERSTANDINGS	TEACHER NOTES
2. Competition	Competition occurs when different species or organisms living in the same environment (habitat) utilize the same limited resources, such as food, space, water, light, oxygen, and minerals. The more similar the requirements of the organisms involved, the more intense the competition.	
EC	If two different species compete for the same food or reproductive sites, one species may be eliminated. This usually establishes one species per niche in a community. The niche is the organism's role in the community.	Reference might be made to the bluebird-starling competition for reproductive sites.
*3. Biomes	The term biome refers to the most common climax ecosystem that will form in large climatic areas. Biomes may be terrestrial or aquatic. The temperate deciduous forest of the northeastern United States is a terrestrial biome. The ocean is an aquatic biome.	
EC a. Terrestrial Biomes	The major plant and animal associations on land are determined by the major climate zones of the world, modified by local land and water conditions. Climates will vary as to temperature, solar radiation, and precipitation. The presence or absence of water is a major limiting factor for terrestrial biomes.	
1) Characteristics	Land biomes are characterized and sometimes named by the climax vegetation in the region. The major land biomes, and their characteristics, flora, and fauna are listed on the following page.	

EC continued

Biome	Characteristics	Climax Flora	Climax Fauna
Tundra	-permanently frozen subsoil	-lichens, mosses, grasses	caribou, snowy owl
Taiga	-long, severe winters; summers with thawing subsoil	-conifers	moose, black bear
Temperate-Deciduous Forest	-moderate precipitation; cold winters, warm summers	-trees that shed leaves (deciduous trees)	grey squirrel, fox, deer
Tropical Forest	-heavy rainfall; constant warmth	-many species of broad-leaved plants	snake, monkey, leopard
Grassland	-considerable variability in rainfall and temperature; strong prevailing winds	-grasses	pronghorn antelope, prairie dog, bison
Desert	-sparse rainfall; extreme daily temperature fluctuations	-drought-resistant shrubs and succulent plants	kangaroo rat, lizard

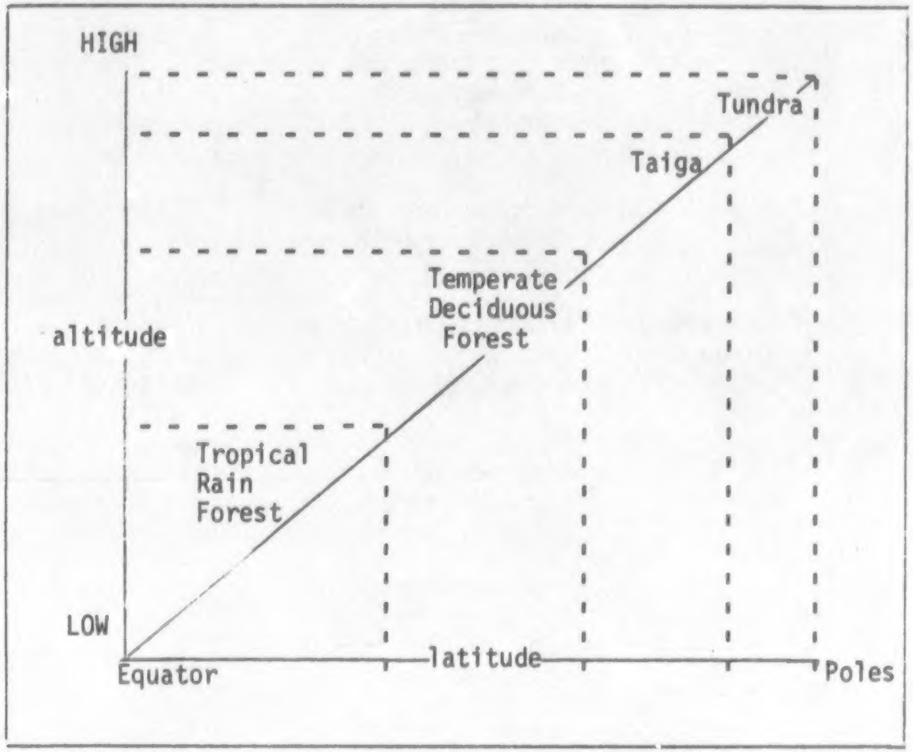
2) Geographic Factors — Climatic conditions change with latitude and altitude.

277

276

TOPICS UNDERSTANDINGS TEACHER NOTES

EC continued


HIGH
Tundra
Taiga
Temperate Deciduous Forest
altitude
Tropical Rain Forest
LOW
Equator
latitude
Poles

278

279

TOPICS	UNDERSTANDINGS	TEACHER NOTES
EC continued		
b. Aquatic Biomes	These represent the largest ecosystem on earth. More than 70 percent of the earth's surface is covered by water and most of the life on the planet exists under conditions where water is the principal external medium. The temperature variation in aquatic biomes is not as great as in the terrestrial biomes, due to the ability of water to absorb and hold heat. In addition, moisture is not a limiting factor. Thus, aquatic biomes are typically more stable than terrestrial biomes. Such factors as the quantity of available oxygen and carbon dioxide, temperature, light, dissolved minerals and suspended particles are the major factors affecting the kinds and numbers of organisms in an aquatic biome. Aquatic organisms are well adapted to remove oxygen which is dissolved in water. They must also maintain a proper water balance. This water balance is affected by the concentration of dissolved salts in the water. Most photosynthesis takes place near the surface of aquatic systems.	
1) Marine	The oceans of the world are a continuous body of water that - Provides the most stable aquatic environment. - Absorbs and holds large quantities of solar heat and helps to stablize the earth's atmosphere. - Contains a relatively constant supply of nutrient materials and dissolved salts. - Serves as a habitat for a large number of diverse organisms.	

TOPICS	UNDERSTANDINGS	TEACHER NOTES
EC continued		
	A great amount of food production in the world occurs in the oceans along the edges of the land masses (coastal waters), the deeper regions being too dark.	
2) Fresh Water	The fresh water biome includes ponds, lakes and rivers. The areas which comprise this biome show considerable variation in: - size - current velocity - temperature - concentration of dissolved gases - suspended particles - rate of succession	
	Ponds and small lakes, for example, fill in due to seasonal dieback of aquatic vegetation and erosion of their banks, and eventually enter into terrestrial succession terminating in a terrestrial climax community.	
*IV. Biosphere and Humans		
*A. Past and Present	Humans, in exercising a unique and powerful influence on the physical and living world, have modified their environment.	
1. Negative Aspects	Natural systems have been upset because humans have not realized that they not only influence other individuals, other species, and the nonliving world, but are, in turn, influenced by them.	

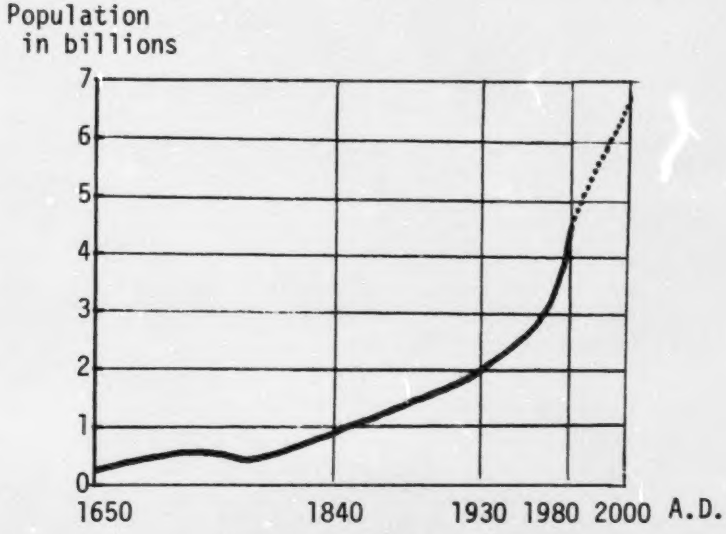
Although most ecosystems are capable of recovering from the impact of minor disruptions, human activities have sometimes increased the magnitude of such disruptions so as to bring about a more lasting and less desirable change in the environment upon which all life depends.

Such disruptions will directly affect at least one of the components of an ecosystem and this, in turn, may affect the remaining components.

a. Human Population Growth

The total population of humans has risen at a rapid rate, partly because of the removal of natural checks on the population, such as disease. This continued increase in the human population has far exceeded the food-producing capacities of many ecosystems of the world. The change in the world population of humans is illustrated below:

The theory of Malthus might be incorporated into the discussion of this topic.



World Population of Humans

TOPICS	UNDERSTANDINGS	TEACHER NOTES
b. Human Activities	Some human activities have led to the extinction or endangerment of numerous species of plants and animals as well as producing less favorable living conditions for many species, including humans. Such activities include:	Use of local examples is encouraged.
1) Overhunting	Uncontrolled hunting, trapping, and fishing still occur in many parts of the world. The extinction of the dodo bird and the passenger pigeon resulted from such activities. Endangered species include the blue whale.	Updated lists of endangered organisms may be obtained through the Department of Environmental Conservation.
2) Importation of Organisms	Humans have accidently and/or intentionally imported organisms to areas where they have no natural enemies leading to the disruption of existing ecosystems. Examples include: the Japanese beetle, Gypsy Moth and disease-causing organisms such as those that cause Dutch Elm Disease.	
3) Exploitation	The exploitation of wildlife, both flora and fauna, for their products and the pet trade has led to threatened populations and ecosystem disruptions. Examples include: the African elephant and the Pacific walrus -- ivory; the Colombian parrot -- pet trade; Tropical rain forests -- plywood.	Human activities 3 to 5 are the forms of habitat destruction which collectively produce the most serious negative impact on the environment.
4) Poor Land Use Management	Increased urbanization/suburbanization claims increasing amounts of agricultural lands, modifies watersheds, disrupts natural habitats (including wetlands), and threatens the existence of wildlife species.	It is estimated that only one in 50 parrots survives the transition from the wild to private collectors.
	Poor land use management practices have led to overcropping, overgrazing, and failure to use cover crops. This has resulted in the loss of valuable soil nutrients and topsoil.	Many years are required to renew lost topsoil.

TOPICS	UNDERSTANDINGS	TEACHER NOTES
5) Technological Oversight	Technological oversights have led to unplanned consequences which have contributed to the pollution of the water, air, and land.	
a) Water Pollution	Major water pollutants include: heat, sewage, and chemicals such as phosphates, heavy metals, and PCB's.	
b) Air Pollution	Major air pollutants include: carbon monoxide, hydrocarbons, and particulates. Nitrogen oxides and sulfur dioxide combine with water vapor creating acid rain problems.	Reference might be made to the water cycle.
c) Biocide Use	The use of some biocides (such as pesticides and herbicides) without a complete assessment of their environmental impact has contaminated the soil, atmosphere, water supply, and has disrupted food webs. Examples include: DDT effects on the bald eagle and peregrine falcon.	Other examples include Dioxin (Agent Orange) and the use of Temick on Long Island.
d) Disposal Problems	The affluent lifestyle of humans currently requires increasing supplies of products and energy, the production of which produces considerable wastes: solid, chemical, and nuclear.	Reference might be made to the problem of chemical dumps such as Love Canal.
2. Positive Aspects	Through increased awareness of ecological interactions humans have attempted to prevent continued disruption of the environment and to counteract the results of many of our past negative practices.	Use of local examples is encouraged.
a. Population Control	Methods of controlling the human reproductive rate have been, and continue to be, developed.	
b. Conservation of Resources	Soil cover plantings (reforestation and covercropping) serve as erosion controls. Water and energy conserving measures are currently being implemented. The economic significance of recycling is now being realized.	

TOPICS	UNDERSTANDINGS	TEACHER NOTES
c. Pollution Controls	Attempts are being made to control air and water pollution by laws and by the development of new techniques of sanitation.	
d. Species Preservation	Some efforts to sustain endangered species have included habitat protection (wildlife refuges and national parks) and wildlife management (game laws and fisheries). Animals which were once endangered but are presently successfully reproducing and increasing their numbers are the bisons and egrets. Endangered animals which are currently responding to conservation efforts and beginning to make a comeback are the whooping crane, bald eagle, and peregrine falcon. The future of some species is still in doubt.	
e. Biological Control	Biological control of insect pests continues to be encouraged. This method is less likely to: affect those species which are beneficial to humans, disrupt food webs, and contaminate the land. Examples include: the use of sex hormones and natural parasites.	
f. Laws	There are laws which regulate and guide the use of natural habitats.	SEQR -- A New York State law designed to provide the opportunity for citizen review and comment of the environmental impact of any proposed development that has been determined to have significant effect on the environment.

TOPICS	UNDERSTANDINGS	TEACHER NOTES
		Freshwater Wetlands Act -- A New York State law designed to regulate the use of large or unique freshwater wetlands both publicly and privately owned so as to prevent their destruction and thus maintain valuable wetlands for all life forms.
B. The Future	While human technological advances have led to a higher standard of living for many, the environment has often suffered. Through a greater awareness of ecological principles, wise use of our energy resources, and concern for future generations not only of humans, but also of all species, each individual can help to assure that there will be suitable environments for succeeding generations.	

DEVELOPMENT OF DISTRICT POLICIES FOR EYE PROTECTION:
SUGGESTED GUIDELINES

The amended Regulations of the Commissioner of Education of the State of New York effective March 1, 1971, outline in general terms the time and place when eye-protective devices should be worn. Boards of education are urged to adopt rules for implementing the Law and Regulations of the Commissioner of Education. Industrial quality eye-protective devices as used in the Regulation are defined as those devices meeting standards of the American National Standard Practice for Occupational and Educational Eye and Face Protection, Z87.1-1968, promulgated by the American National Standards Institute, Inc.

Therefore, the following are provided as guides to implementation of eye-safety programs. It is suggested:

- That school districts formulate specific policies for the implementation of eye-protection programs.
- That school district committees for developing district policy relating to eye-safety devices include:
    - professional staff members representing instructional areas
    - community resource persons familiar with industrial eye-safety programs
    - school district insurance representative(s)
    - optometrist or other medical authority
    - school district legal authority
- That policies be reviewed periodically to implement amendments to the legislation and the Regulations of the Commissioner.
- That suppliers be required to meet or exceed the standards of the American Standard Practices for Occupational and Educational Eye and Face Protection, Z87.1-1968, promulgated by the American National Standards Institute, Inc.
- That sanitary storage facilities relating to eye-protective devices be planned for each shop, laboratory, or instructional area where eye-protective devices are required.
- That quality eye-safety devices be available for the protection of all students in classes where potential hazards exist.

CREATIONISM AND EVOLUTION

There are several views regarding origins and changes that have occurred on the earth over time. Six-day creation, gap creation, progressive creation, theistic evolution, creationism, evolution, and planetary seeding are terms used to describe some of these views. The contrasts among these ideas, especially between creationism and evolution, have been discussed publically.

During the process of revising the Regents Biology Syllabus, suggestions for including creationism as part of this course of study were forwarded to the New York State Education Department. It was suggested that the topic Modern Evolution be replaced by a two-model approach involving creationism and evolution.

The State Education Department requested expert scientific examination of this suggestion in terms of its bases in modern science and its appropriateness for the state high school biology curriculum. The American Association for the Advancement of Science, the American Institute for Biological Sciences, the National Association of Biology Teachers, and the New York Academy of Sciences reviewed the creationism materials and made recommendations as to their inclusion in the science curriculum. Department staff members met with representatives from these scientific associations to review their expert opinion concerning the use of creationism materials in high school science courses.

Their opinion was that creationism does not qualify as information generated by scientific processes and is not part of the body of scientific knowledge accepted by most scientists. Also expressed was the view that creationism can neither be verified nor refuted through scientific investigation and that models or theories which involve the supernatural are not within the domain of science. Accordingly, the following are recommended:

1. Contrasting religion with scientific theories is not the role of the science teacher. Students should be informed, however, that there are supernatural accounts of origins outside the domain of science.* These accounts are derived mainly from scripture and religious authority and are beyond the scope of scientific investigation. The personal religious beliefs of an individual are safeguarded by the Constitution and should be respected.

2. It should be understood that "scientific creationism" is not accepted as science by the majority of experts working in those fields of science related to origins. It is considered by these experts to be a field of study more closely related to religion than to science.

3. Evolution should be taught, not as a fact, but as a scientific theory which has substantial support from the scientific community. The concept of modern evolution incorporates the work of many scientists. Current dialogues among scientists are indicative of possible modifications in evolutionary theory.

4. Teachers should respect the personal beliefs

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*see Teacher Note pp. 108-109.

of students and recognize that in a pluralistic society, the personal beliefs of some may not be compatible with all aspects of evolutionary theory.

The teaching of the supernatural accounts of origins by science teachers in science classrooms as part of the science curriculum is not a recommended procedure. Science teachers should acknowledge the personal validity of their students' beliefs and direct the student to the most appropriate counsel for assistance in questions outside the scope of the science classroom. Technical questions beyond the training and background of the science teacher about the fossil record, homology, biochemistry, etc., should be directed to specialists in those fields. Questions related to scripture, revelation, and the supernatural should be directed to the religious authorities on those topics.

GUIDELINES FOR THE USE OF VERTEBRATE ANIMALS IN ELEMENTARY AND SECONDARY SCHOOL PROGRAMS OF NEW YORK STATE

The study of living things is essential to effective instruction in the life sciences including agriculture. If students are not given the opportunity to study directly living organisms, they will be deprived of basic understandings necessary to comprehend and appreciate life and life processes and to develop competencies needed in agriculture and science-related careers.

The teacher's primary goals for demonstrations and investigations involving animals are to achieve an interest in and an understanding of the life processes, to demonstrate biological principles, and to teach proper care and handling of animals. Such instructional activities, investigations, and projects must be well-planned and adequately supervised, and must be conducted with a respect for life and an appreciation of the health and safety of both the animals and the students. Well-planned investigations or projects should include appropriate preparation and an outline of the stages of the activity. In student-designed activities, both the initial plan and subsequent modifications must be approved by the instructor.

In any segment of society, the abuse of any living animals for experimentation or any other purpose is intolerable. Because agriculture and the life sciences deal specifically with living things, educators must be especially cognizant of their responsibility to insure the humane treatment of living organisms. This responsibility to encourage humane treatment of animals should extend beyond the confines of the teacher's classroom.

In harmony with Section 809 of the New York State Education Law, these guidelines should be followed when studying vertebrate animals in all elementary and secondary school programs in New York State.

A. Biological studies should lead to and be consistent with a respect for life and all living things. Proper treatment and care of animals should be an integral part of any lesson that includes living animals.

B. Investigations dealing with animals must be within the comprehension and capabilities of the students involved. It is recognized that, within a group of students, capabilities may vary; however, it is expected that a competent teacher can determine an appropriate level of investigation for a group or for an individual student.

C. Lower orders of life such as protists and invertebrates can reveal much basic biological information, and when possible, should be used as subjects for invasive studies.

D. Vertebrate animals are appropriate objects of study when students:

   1. observe normal living patterns of wild animals in the free-living state or in zoological parks, gardens, or aquaria;

   2. observe normal living patterns of pets, fish, or domestic animals;

   3. observe biological phenomena involved with (a) embryonic development, (b) inducing ovulation in frogs, (c) imprinting studies, (d) positive reinforcement studies, (e) environmental students, and (f) anatomical and physiological studies;

   4. gain direct, practical experience in developing skills in standard practices used when working with domestic and wild animals.

E. Vertebrate animals used in instruction should be properly cared for.

   1. The procurement and use of wild or domestic animals must comply with existing local, state, or federal regulations. Teachers should assure that live animals entering a classroom are healthy and free from transmissible disease or other conditions that may endanger the health of humans or other animals. Some wild animals are not appropriate for classroom use because they may be carriers of parasites and disease and/or may not adapt well to the conditions imposed by captivity. The use of wild animals as pets should be strongly discouraged.

   2. The care of animals should be supervised by a teacher knowledgeable about proper animal care. An animal may be taken to a student's home only with permission from the parent, and should be provided with conditions similar to those prescribed for classrooms.

   3. Animals being studied must have appropriate quarters; sufficient space for the normal behavior and postural requirements of the species; proper ventilation, lighting, and temperature control. Adequate food and clean drinking water shall be available. Quarters should be cleaned on a regular basis and located in an area where undue stress and disturbances are minimized.

   4. For reasons of conservation, efforts should be made to protect depleted animal species such as Rana pipiens (leopard frog). The same educational objectives can frequently be achieved using alternative species or pursuing alternative methods of study.

   5. Adequate plans should be made to separate the sexes to control possible unwanted breeding of the species during the project.

6. Preliminary plans should include provisions for the proper disposition of the animals at the conclusion of the study or instructional unit. Laboratory-bred or non-active species must not be released into the wild. Native animals should be acclimated to their natural habitat before release.

7. The plan for an extracurricular project involving animals should be reviewed by a qualified adult supervisor before the project begins. An extracurricular project should be conducted in a suitable area in the school or at a site approved by that supervisor.

8. Supervised occupational experience programs usually require the use of animals owned by students, parents, employers, or the school. Prior to the use of these animals, instruction on the proper care of the animal must have been provided.

F. Studies using vertebrates should be carried out with a respect for life.

1. Animal studies should be carried out under the supervision of a qualified teacher. A student should not be allowed to take the animal home to carry out an experimental study. Such a study should be done in a suitable area in the school. A student may, however, take an animal home during periods when school is not in session in order to provide suitable care.

2. No live vertebrate animal should have performed on it a lesson or experimental study that employs (a) microorganisms which cause disease in man or animal, (b) ionizing radiation, (c) known cancer-producing agents, (d) chemicals at toxic levels, (e) drugs producing pain or deformity, (f) extremes of temperature, (g) electric or other shock, (h) excessive noise, (i) noxious fumes, (j) exercise to exhaustion, (k) overcrowding, (l) paralysis by muscle relaxants, (m) starvation, or (n) other extreme stimuli.

3. If bird embryos are subjected to invasive or potentially damaging experimental manipulations, the embryos' development must be terminated three days prior to hatching. If normal embryos are to be hatched, satisfactory provisions must be made for the care of the young birds.

4. On rare occasions the performance of a surgical procedure or the need to terminate the life of an animal for educational purposes may be necessary. Such use of vertebrates is not appropriate below the secondary level. Surgical procedures should only be performed under the immediate supervision of a biomedical scientist using appropriate anesthesia and facilities properly equipped to carry out such procedures. This person must have an appropriate advanced degree such as a Ph.D., M.D., D.V.M., D.D.S., and must be actively engaged in the field under investigation. Agricultural practices such as tail docking, dehorning, and castration, should be taught under the supervision of a D.V.M. or a qualified agriculture teacher. Terminating the life of an animal shall be done in a rapid and painless manner by a person trained and proficient in these techniques. Maximum efforts should be

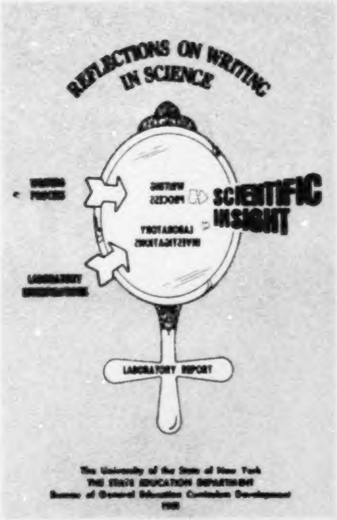
302

303

made to study as many biological principles and utilize as many body tissues as possible from a single animal.

5. A project which involves living vertebrates must display a statement signed by both the teacher and the student to certify strict adherence to these guidelines.

WRITING IN SCIENCE



The publication, Reflections on Writing In Science, has been developed to assist administrators and secondary science teachers in the integration of the skills of writing with the outcomes of successful laboratory experiences. Sections are devoted to the composing process and its relationship to the science laboratory model, to techniques for evaluating writing, and to the spectrum of laboratory activities.

Although this publication has been designed for secondary science teachers, the information contained within it may be generalizable to other content areas. Some comments are included that refer to special requirements of Regents courses of study in science.

Copies are available for each secondary science teacher when ordered by the principal. Order from:

New York State Education Department
The Bureau of General Education
Curriculum Development
Room 314-F EB
Albany, New York 12234

OTHER RECOMMENDATIONS

The Department has, over the years, issued a number of bulletins, advisories, and interpretations of Education Law, Commissioner's Rules, and Regents Regulations in addition to the ones included on the preceding pages.

These are listed below by title with the understanding that, if the school does not have the material readily available, it may be requested by writing to the Bureau of Science Education.

- Certificate of Need for Educational Use of Hypodermic Syringes and Needles Pursuant to Section 811, Education Law.
- Potential Health Hazards (April, 1976)
  - -Asbestos
  - -Carcinogens
  - -Mercury
- Potential Hazards - Picric Acid (February, 1979)

NOTES